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Nothing great was ever achieved without enthusiasm.—Emerson

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# SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXV DECEMBER, 1935 WHOLE NO. 308

## MATHEMATICS FOR THE NON-COLLEGIATE

BY JOSEPH A. NYBERG
*Hyde Park High School, Chicago*

After offering to schools a textbook[1] of unusual contents, an author may be pardoned if he supplements the preface of the book with a more detailed explanation of his aims.

Although teachers are considered very conservative no one can question their persistent effort to fit the courses in mathematics to the varying needs of the pupils and the changing conditions in secondary schools. The experiments with correlated or general mathematics, which began twenty years ago, hoped to improve the preparation of those who went to college (by rearranging the work so that it would be easier for the duller aspirants) and at the same time to offer something useful to those who did not go to college. Teachers held to the assumption that the mathematics which prepared for college was also the best mathematics for those who did not go to college. As a slight concession to the backward pupils the teachers assumed that the easier work on equations, factoring, and fractions has as much value as the more rigorous work expected of the better pupils. When the assumptions began to be questioned courses on minimum essentials were planned, and more and more of the easier algebra and geometry was introduced, and $x$, $y$, and $z$ groups were formed. The result was that administrators and curriculum planners decided that the new mathematics benefited none of the groups and they began to omit mathematics entirely as a requirement. The teachers naturally protested

[1] Survey of High School Mathematics, American Book Company.

voluminously and maintained that there must be something mathematical that all pupils ought to have. The difficulty was in deciding just what this something was.

We are therefore now launching a new attempt to prove that there does exist some mathematics to which every pupil can profitably devote a year of his time. The new attempt is based on the realization that the traditional courses in algebra and geometry (before they were emasculated) were well written for those who went to college and that an entirely different collection of material and treatment is needed for the non-collegiate. Instead of trying to find a compromise that would fit both groups we need two distinct courses in mathematics.

By the term *non-collegiate* I mean pupils like the following:

1. Some pupils of various degrees of intelligence who are not likely to attend college for financial reasons. Many of these could do the traditional work in algebra and geometry. However, since they may not remain in school more than a year or two they could profit more by a survey of high school mathematics than by a single year devoted to algebra. If conditions are favorable they could later do the usual work in algebra and geometry.

2. Some pupils whose ability is such that they would find the usual courses in algebra and geometry difficult. Many of this group plan to enter college or are expected to attend by their families. However, they could pass the usual courses only by devoting more than the customary time to the work. Because they must have extra help to meet the college requirements this group is called non-collegiate.

3. Some pupils who are in school merely because the law or local custom compels them to be there. Most of this group have no interest in any mental activity and are often called motor-minded. Many become prosperous useful citizens, interested in golf and motor cars and seldom read a book after leaving school. Many fail in their high school work whether in commercial courses, shop-work, household arts courses, or any other course.

What mathematics shall the non-collegiate study—or be exposed to? In general, the first group mentioned above needs to be taught the mathematics that is useful. The second group needs to have the past deficiencies discovered and corrected, and the way prepared for their future algebra and geometry. The third group could be speeded toward graduation by an *in-*

*formatory* course in mathematics. Many attempts have been made to find out what mathematics is useful to the average citizen. Although we dislike to admit it, we are close to the truth when we say that so little is useful (to the non-collegiate) that the critics are almost right in saying that these pupils should entirely omit mathematics. But if we discard the word useful, which is difficult to define, and substitute the word *informatory* as explained in an article[2] by Judd of the University of Chicago, then we shall find that there is much mathematics that every pupil can profitably study.

In a discussion of the non-collegiate type by Virgil Mallory in a recent article,[3] the list of objectives is:

The functional relation
Statistical and algebraic graphs
The general number
The formula
The equation
Intuitive geometry
Indirect measurement
  By scale drawings and similar figures
  By trigonometry
A unit of demonstrative geometry
Geometric constructions
Social arithmetic
The use of tables
The slide rule

My experience leads me to almost the same objectives:

1. Review of fractions and decimals with applications to problems on mensuration. This kind of work is often discredited. The critics say that the pupils are not interested in it because it is a review of eighth grade work. However, the work is much neglected in the grades, other material having been substituted for it. Further, it can be made interesting if we do not demand that the pupils become computational experts but devote more time to discussing different kinds of areas and solids, discussing how volumes depend on base and height, how we express this dependence, and aim to familiarize the pupil with geometric figures.

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[2] Informational Mathematics Versus Computational Mathematics, *The Mathematics Teacher*, April, 1929, pp. 187–196.

[3] A Course in Mathematics for Pupils not going to College, *The Mathematics Teacher*, Oct. 1932, pp. 340–346. Mallory's text, based on these ideas, is Mathematics for Everyday Use, Benj. H. Sanborn & Co.

2. Formulas. Again the non-collegiate need not become experts in using formulas. The emphasis is on giving information about formulas: what they are, why they are useful, and examples of some of the more interesting ones.

3. Statistical graphs. Only the better pupils are asked to construct the graphs. The other pupils *talk* about them, interpret them. In the last decade the variety of graphs has increased rapidly and much time can be spent just in getting acquainted with them. The increased attention given to economic and social questions makes the topic more interesting to-day. We need information about seasonal variation, weighted averages, and normal conditions.

4. The Metric System. It is not expected that the non-collegiate will make great use of the metric system but he needs information about it, and no other class in school supplies it.

5. Equations of the type $ax=b$. Too often equations are introduced by asking the pupil how many pounds of sugar he can buy for 30 cents at the rate of 6 cents a pound. The introduction to equations can be improved by using them to solve the three kinds of percentage problems. If the percentage problem is written as an equation one rule will take the place of the usual three cases. This is a genuine justification for the study of equations.

6. The History of Numbers and Mathematics. Instead of scattering bits of history through the year I find it more satisfactory to make an early unit of history, and then use the material as background for later remarks.

7. Positive and Negative Numbers. The pupil need not become an expert on the four operations but he should know that such numbers exist and be able to interpret a negative number when he sees it. He can appreciate the fact that the use of signed numbers reduces the number of rules and formulas needed to express our ideas.

8. Equations. Some work on equations containing parentheses or fractional coefficients is needed as a preparation for other topics.

9. Ratios and Proportions. Because of the prominence of proportions in geometry we have neglected the arithmetic problems that can be solved by proportions. Further, the pupil who would never need to solve such problems needs instruction in the way we use the word proportion to express ideas, as in the statement: The employees maintain that their wages have not

risen in proportion to the increase in the cost of living. To the non-collegiate an understanding of the word is more important than its use in problem solving.

10. The Language of Algebra. The object is not to learn how to perform algebraic operations but to learn how we use symbols to express an idea, with particular emphasis on generalizing problems. In traditional algebra we call this work *literal equations and problems*. In the survey course we do less of the work and spend more time discussing why it is valuable both in mathematics and in other fields. The object is to show what a mathematician does just as we might visit a chemical laboratory merely to see how a chemist spends his time.

11. Square Roots.

12. Similar Figures.

13. Approximate Numbers. Significant figures. Consistent measurements.

14. Trigonometric tables.

15. Geometry. Besides teaching some of the simpler constructions this topic has two more important aims. (a) Enough discussion of axioms, definitions, and theorems to illustrate what is meant by a logical proof, and an attempt to apply logical reasoning to non-mathematical situations. (b) An illustration of how any science grows by passing through the stages of experimentation, classification of results, proofs of the general principles, and the application of those principles to new problems. Thus this unit involves a great deal more than the usual intuitive geometry.

16. Logarithms and the Slide Rule. Again the object is not to make computational experts but to show the pupil how clever mathematicians are; that is, to show some of the things that mathematics has done and can do.

17. Social problems dealing with money, banking, saving, interest, and the kindred problems that are found in eighth grade textbooks but are beyond the pupil's understanding at that time. Most of the time is spent in getting acquainted with the vocabulary and the commercial situations on which the problems are based.

No class could cover all this material in a year. There are $x$, $y$, and $z$ groups even among the non-collegiate. There must be some material for the bright pupils who would like to become computational experts, some material for those who will enroll in algebra and geometry later, and some material for those who merely want to pass the time.

The survey course differs from the older courses in general mathematics in that it frankly does not prepare for college. It involves the simpler arithmetic that the grades are neglecting. It is unlike the practical courses in mathematics which are intended for pupils who would do shop work or enter the mechanical trades. It should be particularly valuable to pupils in commercial courses because it gives a wider view of mathematics and prepares for the required courses in economics. It should be valuable to girls in Household Arts courses. The survey course takes care of those pupils whom we have long wished to eliminate from the traditional courses because they hindered the progress of the collegiate group. There is no doubt that as the survey courses increase, the regular courses in algebra and geometry will lose much of that softness which they acquired when weaker and weaker pupils had to be accommodated. Finally, in the survey course we shall find much that is so interesting and educational that the administrators will be forced to admit that no pupil should be allowed to graduate without some training in mathematics.

An important question is: How shall the non-collegiate be detected among our pupils? At Hyde Park we tried for some time to get the necessary information from the teachers of the eighth grade. The pupils whom these teachers classified as non-collegiate invariably chose the commercial course upon entering high school and invariably failed in business arithmetic. In fact, the failures in business arithmetic were so high that this subject has been eliminated entirely and the necessary arithmetic is taught in the bookkeeping classes. We now place in the survey course the pupils who have tried algebra and failed, and pupils whose high school work shows that they are non-collegiate. An intelligence test is of no value because the survey course is also intended for some very bright pupils. Many bright pupils cannot attend college and cannot even stay long in school. Many pupils are loathe to admit that their families cannot afford to send them to college. Many insist on beginning algebra although their entire past history predicts failure. As is often the case, the patient refuses to follow the doctor's advice. Because of the hold that the words algebra and geometry have on many parents it is difficult to convince the entering pupil that if he cannot enter college the survey course is better than the traditional work.

# PHYSICS DEMONSTRATIONS ON THE COMMENCEMENT PROGRAM*

By Wilbur J. MacNeil
*Punahou Academy, Honolulu, Hawaii*

(Illustrations by Sherborn Smiddy)

It is a far call from the pursuit of pure science in the laboratory to poking around in junk yards, but in our teaching of elementary physics we want to acknowledge the debt we owe to the various junk dealers of Honolulu and the Army and Navy Salvage depots. At small expense we secure a variety of materials all holding infinite possibilities. When the students have finally converted these materials into some form of laboratory equipment, they have attained a double objective. They have clinched some principle in their own minds by putting it into a tangible form, and they have provided a demonstration, not only clear but sufficiently striking to appeal to the boy of high-school age.

A group of seven boys, thinking that some of the experiments which had interested them might also interest their parents, agreed to give a physics demonstration as a part of the commencement program of the Academy. The junk yards, as usual, furnished most of the equipment. For this they decided to demonstrate the principles of a few outstanding electrical machines—the dynamo, motor, and transformer and to show the correlation of these by showing the dependence of each on the magnetic field. The apparatus which they used was made largely in the physics laboratory or in the manual arts shop connected with the School.

Two coils of wire with iron cores, weighing in all about 400 lbs., were purchased from a junk dealer and the boys made them into a big electromagnet by adding yoke and pole pieces as shown in Fig. 1. (The pendulum in this figure has nothing to do with the first demonstrations.)

To show the principle of the dynamo a table galvanometer with a 14″ face and a large indicator had its terminals connected to a single loop of wire about 10 ft. long. While the magnet was actuated a portion of this loop was passed between its poles. The movement of the indicator of the galvanometer

* Students taking part in this demonstration were: William Hole, Kenneth Lau, William Ludders, James Muir, Jr., Walter Naquin, Richard Tam and Richard Young.

showed that a current was produced in the wire. By using several turns of wire, instead of one, to cut the lines of force between the poles of the magnet, or by moving the wire faster or by strengthening the magnetic field, a greater movement of the indicator was produced. The several parts of this experiment were intended to show that the principle of the generator is based on magnetism and motion, and that its voltage depends on the rate at which the lines of force of the magnet are cut by the coil.

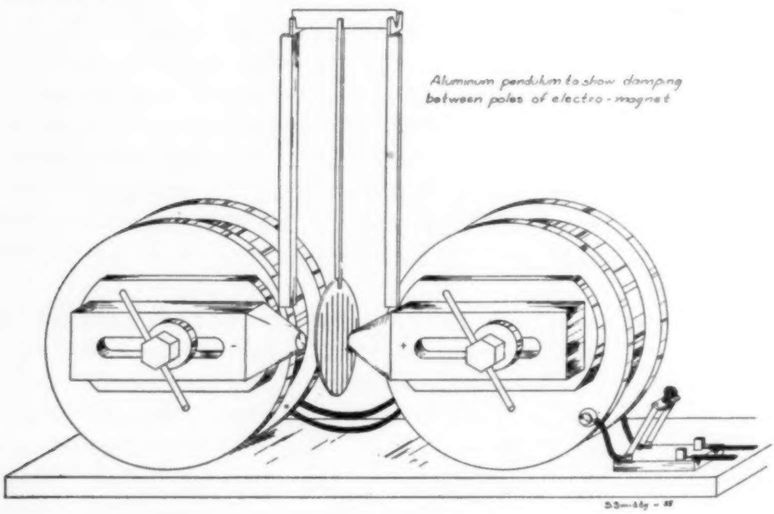


FIG. 1

To demonstrate the principle of the motor this same magnet was used, but now, instead of producing a current by pushing a wire between the poles, a wire was hung vertically between the poles. The magnet was actuated; then a current of 20 or 30 amperes was sent through the vertical wire from a storage battery. Instantly the wire was thrust forcibly sideways at right angles to the direction of the lines of force of the magnet. The current in the vertical wire was reversed and the wire was thrust in the opposite direction.

Eddy currents, useful in damping the motion of the rotating disc in our common watt-hour meter, were illustrated by dropping an aluminum disc between the poles of the magnet. The fall of the disc was, of course, retarded by the induced currents produced in it. A second disc was slotted to eliminate eddy currents. This showed little retardation in its fall when

dropped between the poles. These discs were then made to serve as pendulum bobs by attaching each to the end of a brass rod as shown in Fig. 1. As might be expected the slotted disc swung freely between the poles but the disc without slots was stopped, when the magnet was actuated, almost as though it were immersed in water.

A fourth experiment illustrated the mutual action of induced and inducing currents on each other. A home-made coil (A, Fig. 2) with a laminated core, weighing altogether about 10 lbs.,

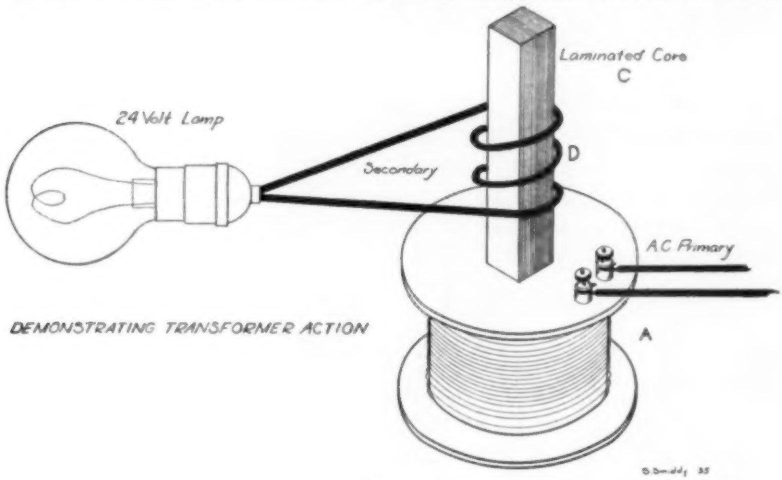


FIG. 2

was placed with the core vertical. An addition "C" to the core extended it up another foot. (The lamp in the figure was not used until the following experiment.) A small coil of wire "B," not shown in the figure, was placed on top of coil "A" and an alternating current sent through "A." Since at any instant the inducing and induced currents were opposite in direction, there was mutual repulsion, and the coil "B" was pushed upward. The effect of the core extension was to follow up this push and throw "B" higher. By making "B" of aluminum and using 220 volts in "A," the coil "B" was thrown more than 10 ft. high. To show that this was really due to the induced currents produced, the coil "B" had its ends disconnected. Since now "B" had no current, it was not thrown up. This same coil (A, Fig. 2) was then used as the primary of a simple transformer. A one-pound coil of No. 18 insulated copper wire was used as the secondary. The latter is represented at "D" in the figure and has its terminals connected to a 24-volt lamp. When

"A" was connected to the 110-volt alternating current, the lamp was brilliantly lighted.

The coils used in the preceding demonstrations would not act efficiently as lifting magnets, and the boys felt that magnetic attraction should be illustrated. Accordingly a so-called iron-clad magnet weighing 150 lbs. (Fig. 3) was made in the School shop. The armature, a 10-inch disc, was bolted to a 2×5 foot wooden platform and the magnet with its load of 1100 lbs. was lifted by a differential pulley. With a current of 10 amperes more than a ton was lifted.

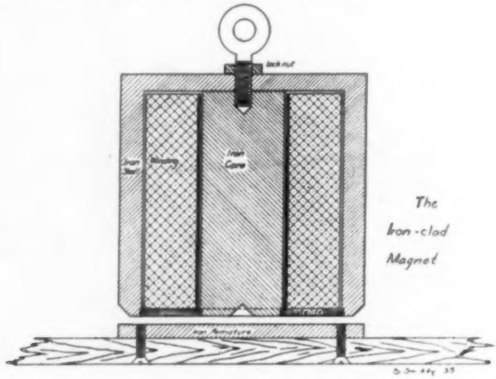


FIG. 3

In these experiments it was shown that an essential factor of the dynamo, the motor and the transformer is a magnetic field. That an electric current is produced by moving a part of a closed circuit across a magnetic field thus illustrating the dynamo principle; that the interaction of a current-bearing wire and a magnetic field may produce motion, thus illustrating the motor principle. In the throwing up of the aluminum coil the interaction of parallel currents in opposite directions was shown, while the transformer principle was illustrated by the linking together of two electric circuits by a single magnetic circuit. In the last experiment we have the unexplained force of magnetism itself which in some way holds together the two steel discs with a force of more than a ton.

The demonstration of these experiments as a part of a commencement program was an attempt to show some of the work that the physics class had been doing. The interest the boys took in making the apparatus and in doing the experiments is, we believe, an indication of the educational value of work of this kind.

# SELECTION OF A HIGH SCHOOL CHEMISTRY TEXT*

BY M. P. SCHULTZ
*Senior High School, University City, Missouri*

A method is described which suggests the possibility of selecting a chemistry text on the basis of its comprehensibility and on the distribution of arithmetical problems in accordance with established laws of learning, principally those relating to initial practice and reviews. The method should be adaptable to other fields.

The primary function of a chemistry text is to convey information through its descriptive material. The problems or exercises are devised for the purpose of review and application of the acquired information. In a manner similar to that of the chemist who speaks of the "available" oxygen in pyrolusite those who are to select a text may think of the "availability" of its information to students, that is, its comprehensibility, and seek devices for pre-determining it.

Chemistry texts used in high school are similar in certain general aspects. Cornog and Colbert (1) have shown that much stress is laid on descriptive matter and useful applications. Even a casual inspection of elementary texts gives the impression that they are very much alike in scope. It might, therefore, seem futile to attempt to select a text on other grounds than the approval of the teacher, or other official, for whatever reason he may have, or on the consensus of opinion of a number of experienced teachers. It is, however, this similarity which proves useful in the method about to be described.

## PRE-DETERMINING THE COMPREHENSIBILITY

For a number of years standardized reading tests have been used to measure the comprehension ability of students. Why would it not be feasible to reverse this procedure and measure the comprehensibility of descriptive material in competing texts by means of "standardized" or equalized groups of students? This question when further considered was resolved into four divisions: Choosing the texts for the competition;

* This article is based on certain major parts of an unpublished dissertation presented to the Board of Graduate Studies of Washington University, St. Louis, Missouri, June 1929, in partial fulfilment of the requirements for the degree of Master of Arts, under the direction of Dr. Stephen C. Gribble, to whom grateful acknowledgment is hereby made.

selecting the topics to be tested; constructing questions and method of scoring them; forming groups of students of nearly equal ability.

It was decided to send letters to cities in each of the forty-eight states inquiring which text was being used. Eighty-four replies were received to a hundred and one inquiries and four of the most widely used texts, according to this census, were selected, and another was chosen locally.

From the descriptive material common to each of these five texts, five topics were selected: Petroleum, photography, Solvay process, blast furnace, blue prints. Mimeographed copies of these with questions concerning each were made in sufficient quantity.

The questions were constructed with the points in view: They must be objective in order to facilitate definite replies and accurate scoring; some questions should be easy and some difficult; they should cover, for the most part, the important subject matter in the topics; they must cover the topics from each text without prejudice. (See questions on "Blue Prints" below.) For scoring each question was given a value of one point.

### Blue Prints

Read carefully the accompanying information about blue prints. Answer the questions below to the best of your ability. You may read the information as often as you need to.

1. Name the compound that gives the paper its blue color.
2. What is the sensitive coating on the paper made of?
3. Name the compound on which the light acts.
4. What name is given to the action produced by the light?
5. Name the compound formed directly by the action of the light.
6. Is the compound formed by the action of the light the same as the compound that gives the paper its blue color?
7. Name the compound (or compounds, if there is more than one) removed when the paper is washed with water.
8. From what part of the paper does the water remove something?
9. Are the parts of the paper from which the water removes something, blue or white after the washing?
10. Name the compounds that react to form the compound which gives the paper its blue color.

Five groups of chemistry students with eleven members in a group were given the twenty-five tests. The groups were approximately equalized by means of chemistry grades. The tests were rotated to compensate for further probable inequalities existing in and among the groups (Table I). Thus while Group 1 was writing on "Petroleum" from text B, Group

2 was writing on "Petroleum" also but from text C, and so on. The next day a similar procedure was followed for "Photography." In this manner each group of pupils examined a different topic from each of the five texts. Absentees wrote upon

TABLE I

Schedule of administering the tests

| Group | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Text | Text | Text | Text | Text |
| Petroleum | B | C | D | E | A |
| Photography | C | D | E | A | B |
| Solvay Process | D | E | A | B | C |
| Blast Furnace | E | A | B | C | D |
| Blue Prints | A | B | C | D | E |

their return to school. There was no time limit set on the tests because the purpose was to determine what the student could accomplish, or perhaps rather what the text could deliver under conditions similar, as nearly as possible, to those a student

TABLE II

Blue Prints

| Text | A | | B | | C | | D | | E | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Score | Time | Score | Time | Score | Time | Score | Time | Score | Time |
| | 8 | 15 | 5 | 30 | 6 | 20 | 5 | 18 | 9 | 12 |
| | 6 | 20 | 9 | 20 | 6 | 21 | 2 | 15 | 9 | 13 |
| | 8 | 25 | 6 | 18 | 6 | 20 | 7 | 20 | 7 | 20 |
| | 7 | 25 | 7 | 15 | 5 | 19 | 10 | 10 | 7 | 15 |
| | 7 | 17 | 7 | 25 | 4 | 13 | 7 | 10 | 8 | 15 |
| | 10 | 15 | 10 | 13 | 2 | 16 | 6 | 20 | 8 | 18 |
| | 7 | 17 | 5 | 15 | 8 | 10 | 8 | 15 | 8 | 15 |
| | 9 | 20 | 6 | 10 | 6 | 5 | 6 | 15 | 9 | 20 |
| | 9 | 15 | 6 | 17 | 6 | 30 | 5 | 21 | 7 | 12 |
| | 9 | 20 | 7 | 31 | 7 | 20 | 5 | 14 | 4 | 15 |
| | 4 | 22 | 7 | 20 | 6 | 20 | 4 | 10 | 10 | 12 |
| Total | 84 | 211 | 75 | 214 | 62 | 194 | 65 | 168 | 86 | 167 |
| Average | 7.6 | 19.1 | 6.8 | 19.4 | 5.6 | 17.6 | 5.9 | 15.2 | 7.8 | 15.1 |

would want or need. However, the time in minutes was recorded with the score in each individual case (Table II). Similar tables recorded the results of the tests on the other topics. The averages were collected and added (Table III).

TABLE III
COMPARISON OF TOTAL AVERAGE SCORES AND TIME OF COMPREHENSION TESTS HIGHEST POSSIBLE TOTAL SCORE, 66 POINTS

| Text | Total Average Score | Total Average Minutes | Percent Average Score |
|---|---|---|---|
| A | 54.2 | 85.4 | 82.1 |
| B | 51.8 | 94.3 | 78.4 |
| C | 48.2 | 88.3 | 73.0 |
| D | 47.7 | 94.0 | 72.2 |
| E | 52.5 | 91.2 | 79.5 |

It is evident that Text A leads with the highest average score and the shortest time average. This result invited further investigation. The tests were repeated the two following years. The text maintained its place with small but, on the whole, consistent margins (Table IV). (The fractional parts of the minutes omitted.)

TABLE IV
COMPREHENSIBILITY OF DESCRIPTIVE MATERIAL FROM FIVE COMPETING TEXTS IN TERMS OF TOTAL AVERAGES OVER A PERIOD OF THREE YEARS

| | Text A | | Text B | | Text C | | Text D | | Text E | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Total Av. Score | Total Av. Time | Total Av. Score | Total Av. Time | Total Av. Score | Total Av. Time | Total Av. Score | Total Av. Time | Total Av. Score | Total Av. Time |
| 1928 | 54.2 | 85 | 51.8 | 94 | 48.2 | 88 | 47.7 | 94 | 52.5 | 91 |
| 1929 | 72.1 | 109 | 70.0 | 106 | 65.7 | 109 | 72.1 | 110 | 68.9 | 113 |
| 1930 | 64.1 | 61 | 60.1 | 59 | 63.6 | 62 | 59.9 | 59 | 61.6 | 61 |
| Sum Total | 192.4 | 255 | 181.9 | 259 | 177.5 | 259 | 179.7 | 263 | 183.0 | 265 |

In the 1929 tests eighty students were available to form five groups of sixteen members each, which were equalized by means of chemistry grades within the limits 81.9–83%. Two sets of questions were lengthened and certain other questions changed while some had their score value changed from one to two points. As in the 1928 tests there was no time limit. The alterations probably account for the larger averages shown (Table IV). The order of administering the tests was also changed. Group 1 would write on "Petroleum" from Text B, while Group 5 was occupied with "Photography" also from Text B, and Group 4 with the "Solvay Process" from the same

text. In other words, a text was disposed of in one day, whereas in the 1928 tests a topic was disposed of.

In the 1930 tests the Iowa Comprehension Tests were employed to organize forty-five students into five groups of nine members each. The order of administering the tests was the same as in 1929. However, a time limit was set, which was based on the single average time of each test previously given. This probably accounts for the shorter average time (Table IV), since some of the students would not need all of the time while the rest would be limited by the time set. This would also influence the scores. The questions were practically the same as in 1929.

One hundred eighty pupils participated in the tests. Only one class was in the second semester. The others were about halfway through the first semester.

Although it is clear from the averages and their "sum total" in Table IV that Text A is likely the one whose information is most readily available, the 1929 test shows that Text D is practically its equal. What would be the deciding factor in choosing between these texts? It is, of course, not intended that three years should be necessary to select a text by this method. The repetitions were made to ascertain whether the method would prove consistent in its results, and to a reasonable degree though with small margins it seems to have done so. If then the selection of a text were to be guided by a single series of comprehensibility tests and the competition was close as in the case of Texts A and D in the 1929 test, it would be natural to resort to examination of other characteristic features among which may be listed the distribution of exercises or problems.

### INVESTIGATION OF THE PROBLEMS

Problems may be used for both initial practice and review. "It is a fact that use up to a certain psychological limit is cumulative in effect. If one response strengthens the connection somewhat, then two responses have a greater effect than one, three greater than two, and so on. Consequently, other things being equal, the more frequently a connection has been exercised, the stronger the connection" (2). This is sometimes called the Law of Frequency.

The number of problems and their dispersion seemed to be the best available means for ascertaining the extent to which

the texts provided for the distribution of practice and recognized the principles of economy in learning. One difficulty arising in connection with the latter is the question of distribution of reviews which does not appear to have found a complete answer up to the present time. "The evidence bearing on the distribution of reviews is insufficient to justify a confident statement but it indicates that one should overlearn somewhat at the beginning and leave the remainder of the overlearning to reviews at constantly increasing intervals" (3) with decreasing amounts of material.

It was found possible to classify the arithmetical problems in the texts into twenty-one different types by considering the category of the answer, weight, volume, density, and so on. However, only the weight and volume problems were numerous enough for comparison (Table V). The remainder were scattered among the remaining nineteen types. Certain texts omitted some types. It was therefore not possible to compare these problems among themselves, but they were included in the

TABLE V
DISTRIBUTION OF WEIGHT AND VOLUME PROBLEMS BY QUARTERS OF THE TEXTS

| | Quarter | | | | |
|---|---|---|---|---|---|
| | 1st | 2d | 3d | 4th | Total |
| Text | | | | | |
| A | 34 | 25 | 22 | 6 | 87 |
| B | 19 | 33 | 25 | 15 | 92 |
| C | 35 | 24 | 14 | 30 | 103 |
| D | 16 | 36 | 39 | 20 | 111 |
| E | 16 | 6 | 2 | 2 | 26 |

TABLE VI
DISTRIBUTION OF ALL ARITHMETICAL PROBLEMS BY QUARTERS OF THE TEXTS

| | Quarter | | | | |
|---|---|---|---|---|---|
| | 1st | 2d | 3d | 4th | Total |
| Text | | | | | |
| A | 63 | 55 | 25 | 14 | 157 |
| B | 25 | 58 | 47 | 20 | 150 |
| C | 61 | 27 | 16 | 38 | 142 |
| D | 40 | 61 | 50 | 36 | 187 |
| E | 26 | 7 | 4 | 4 | 39 |

comparison of the total (Table VI). The distribution of the problems by quarters of the texts was adapted from the distribution by chapters as originally made, which is too voluminous to include here.

The fact that Text A appears to have its problems distributed better according to the principles of practice and review as far as these have been established might be the cause of its selection instead of Text D. It is realized that other factors such as being up-to-date, binding, clearness and number of illustrations, sequence of chapters, author, etc., may influence the selection of a text. However, the best text is the one which is most comprehensible to the student, everything else being equal. It might be maintained by some that greater comprehensibility would outweigh differences in other respects, for instance, a higher price, a new author, or a certain sequence desired by the teacher. Be this as it may, it is practically certain that the teacher does the very best he can for the pupil when he ordinarily selects a text. However, he can not tell how well the text is comprehended until it has been in use for some time, and then he can only surmise how much better or worse it is than another new text he might have chosen. The difference in comprehensibility in texts can best be pre-determined by their simultaneous exposition to the pupils who are to use them.

It is probably a safe policy to select a widely used text. This assumption seems to be supported by the results of the tests, for Text A was by far the most widely used and is also shown to have the best score. The agreement of these two items might serve to increase the confidence in the selectivity and validity of the method to the end that its use might be extended to the examination of entirely new chemistry texts, as well as to texts in other fields, for instance Social Science. It is hoped other investigators will be sufficiently interested to undertake work which will tend to establish the method more firmly or eliminate it.

## CONCLUSION

Assuming that the method has shown the existence of a true difference in comprehensibility, it might be interesting to speculate on what causes the difference. It can not be due to the vocabulary entirely, for the vocabulary burden of the texts was determined by the Lively-Pressey method (4). It was found that Texts A and E, which have the highest score (Table IV),

also have the greatest technical vocabulary and range when compared with the Thorndike word list (5). However, since it is intended to use that information as basis for another article, let it be sufficient at this time to assign the chief reason for the differences in the comprehensibility of the topics to that which Webster defines as the "choice of words for the expression of ideas; the construction, disposition and application of words in discourse, with regard to clearness, accuracy, variety, etc.," namely, diction.

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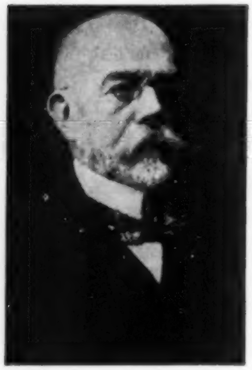

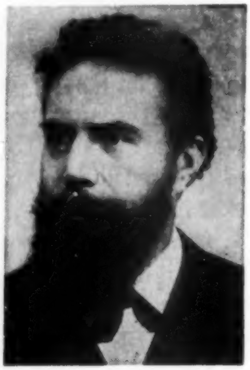

MEDICAL IMMORTALS

Successful progress in the fight against tuberculosis is made possible chiefly by the discoveries of these three men. Robert Koch (left) noted German research worker, discovered the tubercle bacillus and proved it was the cause of tuberculosis in 1882. Rene Theophile Hyacinthe Laennec (center) young French medical genius, invented the stethoscope in 1815. When only 45 he became a victim of the disease he did so much to help conquer. Wilhelm Konrad Roentgen (right) noted German physicist, discovered in 1885 what is probably the most important diagnostic aid in modern medicine—the X-ray.

# A DEVICE FOR TEACHING THE OPERATION OF THE SEXTANT

By John B. Leake
*Crane Technical High School, Chicago, Illinois*

The sextant is an interesting scientific device because its operation leads to study of geometry, geography, astronomy, mathematics and charts.

Formerly the sextant was considered an instrument of practical use only to mariners, but now that every pasture is a port from which men may go aloft to fly out of sight of land, farm boys can see a reason for its use. Just as boys once hoped to become railroad men, they now experiment with planes, and hope to pilot clipper ships to China.

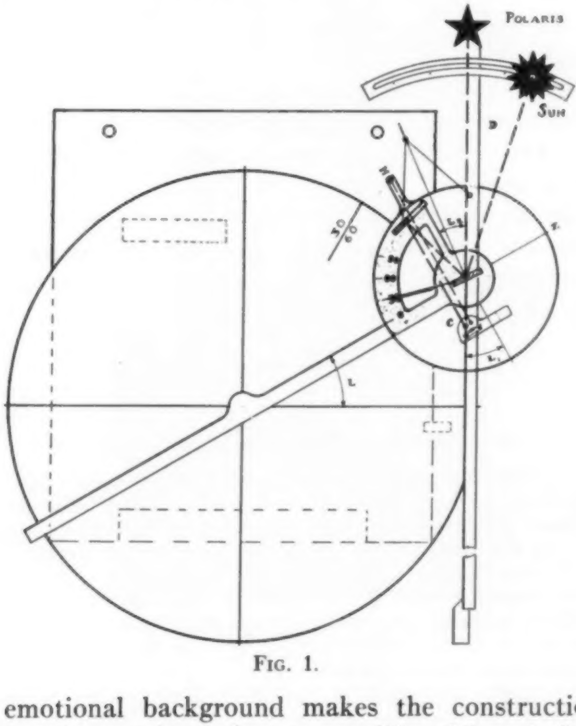


Fig. 1.

This emotional background makes the construction of a sextant, and instruction in its use, possible, although the landsman does not have the sailor's experience as to earth curvature, and star constellations.

To graphically illustrate the operation of the sextant at different latitudes, when sighting the north star or the sun, the

author devised the apparatus shown in the drawing. It has been tested in class use, with good results.

The device is operated by pulling down on the left end of the horizontal arm, causing the sextant disc to move upward over an arc of ninety degrees. The weighed arm maintains the sight to Polaris parallel to the vertical polar axis of the earth. Thus the sextant reading gives the latitude angle, north of the equator. The angles of incidence and reflection are maintained equal by the two wires which act on the rod normal to the moveable mirror.

In using the device to illustrate "shooting the sun," the equator is considered to be the vertical diameter of the large disc, and the north pole to be the right end of the horizontal diameter. To allow for the sun's declination, on any date, the sun can be moved along the arc, thus setting the declination angle. This angle is secured by consulting the ecliptic on a globe, or from the Nautical Almanac.

This device can be further improved, by masking certain portions, and arranging colored segments attached to the moving arms, so that equal segments of the same color will be exposed over equal angles.

Satisfactory sextants can be made from $\frac{1}{4}''$ plywood and two small mirrors, and these, with the device illustrated, have proved valuable in introducing the student to a number of scientific subjects.

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## NEW PERMANENT MAGNETIC ALLOY

A new magnetic alloy, whose permanent magnetism is so powerful that it will lift sixty times its own weight, was shown at the laboratories of the General Electric Company on the first stop of the Tour of Industries being sponsored by the engineering division of the National Research Council, for business and banking executives.

The new magnetic alloy shown to the visitors at the General Electric laboratories is made of aluminum, cobalt, nickel and iron, and will have important applications in the radio industry for the construction of high-quality radio loud-speakers at low cost.

Present dynamic loudspeakers, said W. E. Ruder of the research laboratory in describing the new development, require strong magnetic fields obtained by use of electromagnets. The new permanent magnetic alloy will replace these more costly electromagnets.

Illustrative of the unforeseen developments possible through scientific research, Dr. Ruder pointed out, is the fact that the new alloy was not originally developed for its magnetic qualities. It was made to serve as a heat-resisting alloy which would not deteriorate at high temperatures.

# A NOVEL CHEMIST-TREE

BY L. E. BLACKMAN
*Kansas State Teachers College of Emporia, Emporia, Kansas*

The botanist has a knowledge of a large number of different kinds of trees; however, the one suggested by the above title is a new species and probably has not been classified as yet. It has been said that of all the trees known, the most fruitful tree from a scientific standpoint is chemistry (chemist-tree). Of course, there is a limit to the artificial trees which man can devise, since as everyone knows, "only God can make a tree." Still, a very novel and attractive tree can be made if the following directions are carried out. This tree is made entirely of apparatus and chemicals found in the chemistry laboratory.

The main trunk of the tree consists of an iron standard about six feet high with a tripod base. The rod is about seven-eighths to one inch in diameter. One could use two shorter rods and clamp them together suitably, or one could also make a smaller tree to start with, if the necessary apparatus is not available. Iron rods of various lengths, such as those from ordinary ring-stands, and tripod legs, clamped together and attached to the main trunk furnish the limbs. The rods can be so placed as to

give a general tapering effect from the base to the top of the tree. Having made this rough skeleton, one can now begin to add the decorative effects.

Ordinary single iron burette clamps are attached to the limb rods in several suitable places. These serve to hold the chemical electric lights. Small flasks, such as 50 cc. Florence flasks, are filled with various colored solutions, corked and inverted, and inserted in the burette clamps. One may put on as many of these flasks as will serve to give the tree a well-lighted appearance. Suitable colors can be made with the following solutions: nickel nitrate for green, potassium permanganate for purple, copper sulphate and ammonia water for a deep blue, eosin (also ferric thiocyanate) for red, potassium chromate for yellow, sodium dichromate for orange, and water made basic with a few drops of sodium hydroxide to which a few drops of phenolphthalein have been added, for a cerise color. Various shades can be produced by dilution with water, or by combinations of different chemicals. Several trials may be necessary to obtain the desired effects.

Red and green rubber tubing appropriately wound in and about the limbs serves admirably to give the effect of Christmas tree rope-streamers. Short lengths of tinfoil about one-eighth inch wide add much to the appearance of the tree. Dots of cotton here and there will produce a snow-effect. A star, made by bending ordinary glass tubing, filled with a blue colored solution and corked with paraffin, makes a very beautiful top-effect on the tree. Glass tubing drawn out to capillary lengths, crinkled tubes, and various shaped capillaries serve very nicely for icicle effects. A large retort, filled with a bright colored solution, and clamped about the middle of the tree, adds much to the general appearance. Various pieces of apparatus, such as are ordinarily found in the chemistry laboratory, are attached to the tree by means of short hooks of copper wire or other similar material. These so-called toys and decorative effects are limited only by the equipment of the local laboratory. Odd and curiously shaped pieces are the more attractive. Needless to say, light weight articles are the most appropriate. Some pieces, when filled with various colored solutions, show up beautifully. A Liebig condenser, with the inner tube filled with blue and the outer jacket filled with red solution, makes a colorful addition. Some articles, like pipestem triangles, when wrapped with tinfoil, aid materially in brightening up the tree.

The base of the tree is covered with several layers of cotton. Snow effect is produced by the use of borax spangles sprinkled on the cotton. The bottom of the tree can be further decorated by the use of two dolls, placed one on each side, and somewhat to the front. These dolls are made from chemical apparatus. A two-liter Florence flask filled with colored solution forms the body part of one doll. A 250 cc. Florence flask filled with another colored solution, corked and inverted in this larger flask, serves for the head. Burette clamps covered with cotton suffice for the arms. A cotton cap or bonnet can be placed on the head. Gummed re-enforcements serve for the eyes. The other doll can be made somewhat differently. A tall 250 cc. graduated cylinder (ungraduated will serve just as well) forms the body and a small Florence flask the head. Each of these are filled with suitably colored solutions. Burette clamps covered with cotton make the arms and legs, and cotton effects are used on the head. One can use a good deal of his own ingenuity on these dolls. They may be labelled with chemical names, such as Moll E. Cule and Al. D. Hyde, or Molly B. Date and Ben Zene. This will serve to carry out the chemical idea of the tree. The tree can be made even more real and effective by placing various colored boxes (for gifts) at the bottom, and adding a few dummy candy bars or other samples to the display.

The tree appears very beautiful and real at night or in a dark room, if it is illuminated at the base by an electric light and reflector, so placed as to direct the light through the tree from behind. This light passing through the various colored solutions produces a marvelous and striking effect.

Chemistry club members take especial interest in the construction of the tree. After the tree has been set up a few times, new ideas will develop and each year it will become more real and attractive. It makes a very interesting project for the holiday season. One should plan to have the tree finished about one week before the students go to their homes for the Christmas vacation. Chemistry clubs might even work out a program for their December meeting and place presents for various members on the tree. Neon lighting effects would also enhance the appearance of the tree materially. By careful planning and construction, one will readily and easily discover that the chemist can actually have a chemist-tree made by chemistry which will serve as an excellent Christmas tree for the pleasure and enjoyment of others.

# A METHOD OF EQUIPPING THE DEMONSTRATION TABLE WITH GAS WHERE CITY GAS IS NOT AVAILABLE

By Thomas Baldwin
*High Point High School, High Point, North Carolina*

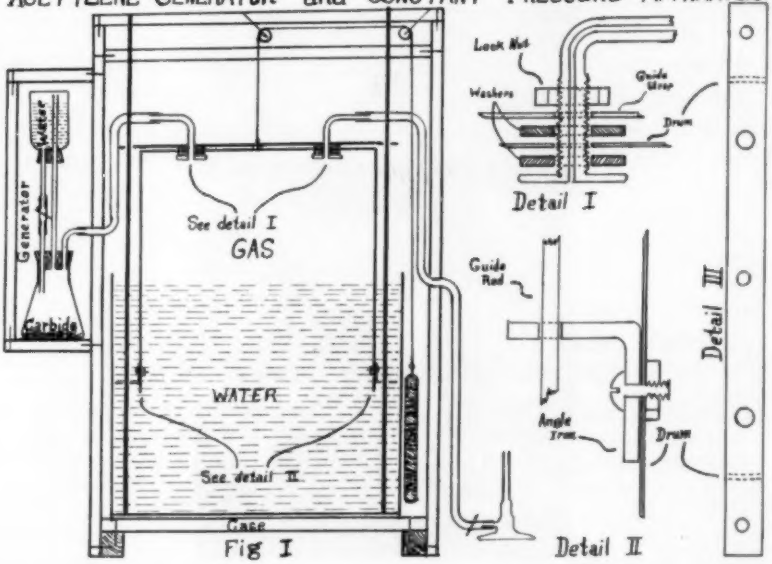
Two lard stands, two bottles, a few odds and ends available in any locality, are all that one needs to equip a demonstration table with gas. This paper is a description of apparatus assembled by the writer to furnish gas for a science demonstration table in a small high school where city gas is not available. It requires very little mechanical ability for assembly, and it has been thoroughly tested under actual laboratory conditions. The cost is negligible, the particular unit herein described having cost $3.50, most of which is represented by the burner. The cost of operation is less than two cents per hour.

The generator, figure 1, can be made from bottles or laboratory flasks ranging from one pint to one gallon in capacity, the only requirement being that a rubber stopper fit in them snugly. The one shown in the sketch consists of a collecting bottle filled with water and containing a two-holed rubber stopper. A short piece of glass tubing, ending in a short piece of rubber tubing, is inserted in one hole. Through the other hole is inserted a longer piece of glass tubing which extends almost to the bottom of the bottle (the top as shown in the sketch). This tube acts as a pressure equalizer, and it extends out of the bottle some distance, its outer end entering the center hole of a three-holed rubber stopper. In one of the remaining holes is inserted a short piece of glass tubing, entering the rubber tube mentioned above. Place a screw compressor type clamp on this tube. A 90° glass bend is inserted in the other hole. This is the gas outlet. The clamp regulates the amount of water flowing into an Erlenmeyer flask in which the three-holed stopper fits and which contains a small amount of calcium carbide. Admit water by drops (caution! rapid evolution of acetylene gas and heat). The writer has used this generator connected directly to the burner, water being admitted at the rate of 20–28 drops per minute, but the auxiliary constant-pressure apparatus described below has obvious advantages.

This apparatus consists essentially of two cylindrical containers, one slightly smaller than the other, and each open at one end. The larger, water drum, figure 1, which can be made

from a large lard stand, steel drum, ash can, barrel, etc., is almost filled with water. Two iron rods of almost any size, which pass through two cross members in the case, figure 1, rest on the bottom of this container. They act as guide rods for the gas drum, figure 1, as it moves up or down. This drum can be made from a smaller lard stand, steel drum, carbide stand, or practically any gas-tight container. To the open, or bottom end, are fastened two angle irons, Detail II, with holes slightly larger than the guide rods which slide through them. On the top, on a line passing through the center, are drilled two

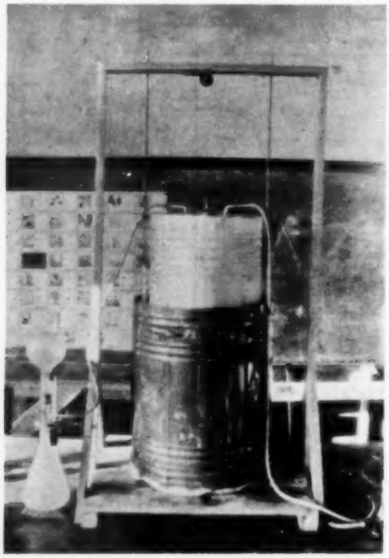
ACETYLENE GENERATOR and CONSTANT PRESSURE APPARATUS




holes, through which are passed two old automobile inner tube valves. The curved type is best. Remove the valve stems, and make all joints gas-tight with gaskets made from old inner tube rubber, as shown in Detail I. A guide strap, Detail III, made of light metal, and with holes drilled so as to coincide with those through which the valves pass, is secured under the lock nuts, as shown in Detail I and figure 1. This strap has a hole in each end through which the guide rods slide, and a hole should be drilled in its center to receive an eye bolt or ordinary long bolt for the attachment of a counter-balance, in case the drum exerts too much pressure due to its weight. The drum should be counter-balanced or weighted experimentally so as

to exert the minimum pressure which will sustain the burner. The apparatus herein described operates at a pressure of 4 mm. of mercury in an open end manometer, at which pressure 35,000 cc. of acetylene, derived from 150 g. (5.25 ozs.) of carbide, will sustain a burner for two and one-half hours.

Connect one of the valves to the generator with ordinary laboratory tubing, and the other similarly to the burner. A screw compressor type clamp should be placed on the burner hose. An acetylene type burner (W. M. Welch Scientific Company, Cat. #4748; Chicago Apparatus Company, Cat. #412C) is required. Expel all air by forcing the gas drum well down into



the water, in order to avoid an explosive mixture of acetylene and air. Start the generator, and the gas drum will slowly rise. Cut off the water in the generator when the drum is about two-thirds filled with gas; because moisture in the generator will continue to react with the carbide for some time. Do not attempt to fill the gas drum with an open flame near, and operate the burner at as great a distance as is convenient from the apparatus.

Calcium carbide can be purchased from the National Carbide Sales Corporation, Lincoln Building, New York City, in one hundred pound lots at about six cents per pound; or from any scientific house in five or ten pound lots at about twenty-five

cents per pound. Since the former quantity is more than the average school would use in several years; and since the latter price is for a quality superior to that required by the apparatus, the writer has arranged with the Gadink Chemical Company Randleman, N. C., to ship carbide in five or ten pound lots at twelve cents per pound C.O.D., plus carrying charges to any address.

This apparatus is not fool-proof, but if common sense is employed in its operation, it is as safe as the private gas plants so commonly used before the days of electricity.

The entire apparatus should be rust-proofed with paint and cased as shown. For a permanent installation, heavier drums and regular gas tubing should be used. Larger drums might be used for more than one burner; although no experiments have been carried out along this line. The assembly of the apparatus would make an excellent student project. Any communications or suggestions concerning this apparatus will be appreciated by the writer.

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## NUMBERS OF FOREST FIRES INCREASE, BUT TOTAL AREA BURNED DECREASES

Forest fires, raging in the Los Angeles region and menacing elsewhere, might have been far worse this fall if the woods had not been full of C. C. C. workers. Latest figures available at the U. S. Forest Service here show that forest fires this fall in National Forests over the country as a whole, have numbered 9,512, as against a preceding five-year average of 7,601—an increase of about twelve per cent. But the total area burned this year has been only 192,040 acres, as against a five-year average of 417,603 acres—a decrease of well over one-half.

Forest Service officials give full credit to the C. C. C. workers for this creditable showing in reduction of loss. In the first place, armies of fire-fighters stand "at the ready" all the time, so that counter-attack against the flames is much more prompt then it used to be. But more basic and permanent has been the work of the C. C. C. in building fire roads, clearing fire breaks, cleaning up accumulations of slash, snags and other forest-fire bait.

A factor in the increase of forest fires, at least in numbers, is the continually growing army of people entering the National Forests, especially recreation-seekers. The number of man-caused fires in the National Forests this season was 5,506, as compared with the five-year average of 4,359 for the 1931–34 period.

Taken by regions, the Forest Service summary of the situation is: Southern California, hazardous; Northeast Atlantic states, medium hazardous; parts of the South, medium to highly hazardous; elsewhere, generally favorable.

# HOW A POLAR PLANIMETER WORKS*

By Allan W. Larson
*Albion College, Albion, Michigan*

## INTRODUCTION

Many machines have been invented to shorten the work of calculating, for as far back as 1642 men were inclined to believe that even some mathematical problems could be done more efficiently by mechanical aid. For instance, Pascal's invention of the adding machine in 1642 gave rise to many developments and was responsible for later modifications permitting not only addition but also multiplication, division, subtraction, extraction of square roots, and many other operations. Nor were these fields of mathematics the only ones affected by the development of machines. Soon the problem of computing areas was attacked by inventors, with the result that the integraph and various forms of the planimeter were developed. In this paper we shall describe how a polar planimeter works in ascertaining the area of a bounded plane surface.

## GENERAL CHARACTERISTICS OF THE PLANIMETER

As mentioned before, the polar planimeter is an instrument specially designed for the purpose of ascertaining the area of any plane surface (no matter how irregular its outline), such surface

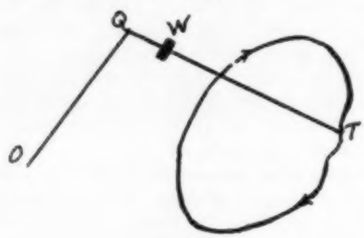



Fig. 1

being represented by a figure drawn to any given scale. Its speed in finding the areas of indicator diagrams, railroad profiles, plots of grounds, sectional areas of vessels, areas of dis-

* For further reference: Encyclopedia Britannica, 11th edition Volume 4, pp. 975–977. Encyclopedia Britannica, 14th edition, Volume 15, pp. 69–70. Raymond, W. G. "Plane Surveying" (1914), pp. 202–209. Cox, Wm. "A Manual on the Polar Planimeter" (1915).

For explanation of the working of the planimeter, using calculus methods, see Williamson, "Integral Calculus" (1916), p. 214 et seq.

placement of floating bodies, and many other calculations, has made it a close friend of the engineer.

The simplest and most useful polar planimeter is Amsler's, which is small and rather delicate. It consists of two metal bars, called the polar arm $OQ$ and the tracing arm $QT$ hinged at $Q$. These arms can be seen in figure 1. A needle point at $O$ is pressed into the drawing board, and the tracer $T$ is moved around the boundary of the figure. At the same time a wheel $W$ on the tracing arm rolls on the paper, and the turning of this wheel measures the area.

### THEORY OF THE MOTION OF TRACING ARM QT

In studying the theory of the polar planimeter, we shall consider the simple movements of the arm $QT$, then combine them

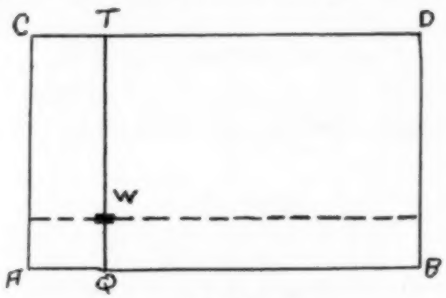



FIG. 2

to get the general motion. In doing this we shall consider $QT$ detached from $OQ$. Place the wheel of the arm $QT$ on the paper, and let the arm describe a rectangle $ACDB$, as shown in figure 2. As the rod moves from $AC$ to $BD$, the area swept out or generated is

$$P = ACDB = sw,$$

where $P$ represents the total area, $s$ denotes the length of the arm $QT$, and $w$ is the number of units rolled out on the circumference of the wheel. The circumference of the wheel is divided into a number of equal parts, say one hundred, and the wheel is of such radius and $s$ of such length, that the area is given in square centimeters, square inches, or some other unit. It is convenient to call $w$ the "roll" of the wheel.

Now, let the rod $QT$ turn about the end $Q$. It can be seen that the tracer $T$ will describe an arc of a circle $AB$, while turned through an angle $\theta$ (figure 3). Thus, the area of the

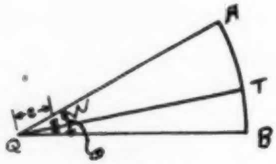




FIG. 3

sector is $\frac{1}{2}QT$ times the arc $AB$. If $c$ is the distance of the wheel from $Q$, or $QW=c$, then

$$\frac{\text{arc } AB}{s}=\frac{w}{s},$$

and $w$ is again the "roll" of the wheel. Multiplying the equation by $s$ gives

$$\text{arc } AB=\frac{s}{c}w,$$

hence, the area generated, or area of sector is

$$BQA=\frac{1}{2}\frac{s^2w}{c},$$

where $s$ and $c$ are constants of the instrument, so the area is determined by the roll $w$.

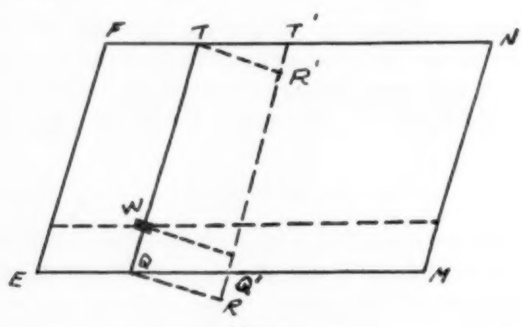




FIG. 4

Another motion of the rod $QT$ is moving parallel to itself, but *not* in a direction perpendicular to itself, as in figure 4. The wheel will slide as well as roll when $QT$ moves from $EF$ to $MN$. To make clear the exact motion of the wheel let us look at an infinitesimal motion of the rod from $QT$ to $Q'T'$. This motion

may be resolved into the motion to $RR'$ perpendicular to the rod $QT$, by which the rectangular area $QRR'T$ would be generated, and the sliding of the rod along itself from $RR'$ to $Q'T'$. During the sliding of the wheel in the second step there is not any area generated, but during the first step the roll of the wheel will be the distance $QR$ giving the area $QRR'T$, which equals the area $QQ'T'T$. Thus we see that as the arm moves from $QT$ to $Q'T'$ the wheel is not only rolling but is slipping, and the slipping that takes place is the sliding mentioned above. Since there is no roll of the wheel in the sliding, the roll gives the desired area $QQ'T'T$. In considering the motion from $EF$ to $MN$ we think of it as made up of a very great number of small steps, each resolved as stated; we can easily see that the roll measures the area generated.

To investigate the most general motion of the tracing arm $QT$, we again resolve the motion of the rod into small steps. Let the initial position be $AB$ and the terminal be $CD$, the step being so small that the arcs over which the ends of the rod have passed may be thought of as straight lines (figure 5). The area

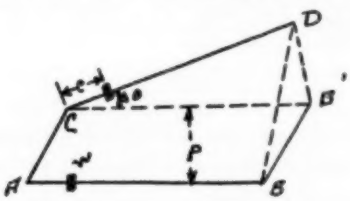



FIG. 5

generated is $ABDC$. As before, we resolve the motion into a step from $AB$ to $CB'$ in which the rod moves parallel to itself, and rotates about $C$ from $CB'$ to $CD$. In the first instance, the "roll" will be $p$, the altitude of the parallelogram $ABB'C$, and in the second it will be $c\theta$. Therefore the total roll will be

$$w = p + c\theta$$

where $c$ is the distance of the wheel from $Q$, and $\theta$ is the angle $B'CD$. From this equation

$$p = w - c\theta.$$

The total area generated is

$$ps + \tfrac{1}{2}s^2\theta;$$

and substituting for $p$ gives

$$s(w-c\theta)+\tfrac{1}{2}s^2\theta,$$

or

$$sw+(\tfrac{1}{2}s^2-sc)\theta.$$

It should be noticed that $w$ is the total roll of the wheel, while $\theta$ is the angle from the position $AB$ to the position $CD$. Now for a finite motion, the total area would be the sum of the areas generated during the different steps. The wheel would make a continuous roll so that $w$ would give the total roll as the sum of the rolls of the successive steps. Let $w$ be the whole roll, and let $\phi$ be the sum of the small turnings going from $AB$ to $CD$, as shown in figure 6. Then the area $ABDC$ is

$$p=sw+(\tfrac{1}{2}s^2-sc)\phi.$$

We can see that $\phi$ is merely the angle from the first position of the rod to its final position. In the proper application of the planimeter, the rod is always returned to its starting position

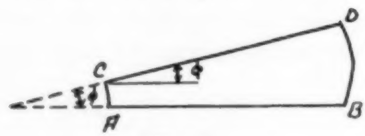



FIG. 6

which means the tracer has traced a closed curve, and the angle $\phi$ is either zero, or it is $2\pi$ if the tracer has turned around $Q$. In the case that the tracer does not turn around $Q$ the area will be

$$P_1=sw.$$

And when the tracer turns around $Q$ the area will be

$$P_2=sw+(\tfrac{1}{2}s^2-sc)2\pi,$$

or

$$P_2=sw+s(\tfrac{1}{2}s-c)2\pi.$$

Since $s(\tfrac{1}{2}s-c)2\pi$ is a constant term it can be represented by $H$, then

$$P_2=sw+sH.$$

The constant $H$ is always the same, as it depends on the dimension of the instrument. Hence, in either case the area generated by the motion of the rod is determined by $w$, the roll of the wheel.

In every case shown we have seen that the area generated

by the motion of the rod is measured by the roll of the wheel. Now we shall show that the rod can generate any closed area. Again we move the rod disconnected from $OQ$, but this time it is moved from its initial position $AB$ in any manner so that $T$ and $Q$ describe closed curves. We next apply the

FUNDAMENTAL PROPOSITION: If a rod $QT$ performs such a motion, the area generated equals the difference of the areas enclosed by the paths of $T$ and $Q$ respectively.

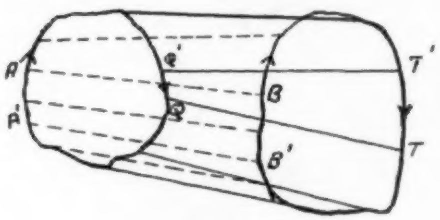



FIG. 7

This fact can be seen from referring to figure 7 in which the motion of the rod is shown by straight lines representing the different positions of the rod. The area between the curves is swept out twice, once as the rod moves upward, and once as the rod moves downward. For this the roll of the wheel will be as much positive as negative, thus giving zero for this area. In figure 7 the closed area $B'BT'T$ is generated as the rod moves upward, while the closed area $A'AQ'Q$ is generated as the rod moves downward. In the motion upward, the wheel will increase its roll, but when the motion of the rod is downward, the roll will be negative. Hence, the resulting roll will be the difference of these two areas. The theorem still holds for more complicated figures. For instance, it may happen that the area within one of the curves will be passed over several times, but it will *always* pass over once more in one direction than in the other.

THE POLAR ARM TOGETHER WITH THE TRACING ARM

We shall now connect the polar arm $OQ$ to the tracing arm $QT$. When the polar planimeter is used, the tracer $T$ describes the closed curve of which the area is to be found. When the tracer is moved on the cruve, $Q$ as shown in figure 8, moves back and forth on the arc of a circle coming to its original position without making a complete revolution, and thus en-

closing no area. The area described by $T$ is then found from the preceding formula

$$P = sw + (\tfrac{1}{2}s^2 - sc)\phi.$$

Now $\phi = 0$, therefore the equation reduces to

$$P = sw$$

which is the "reading" of the wheel.

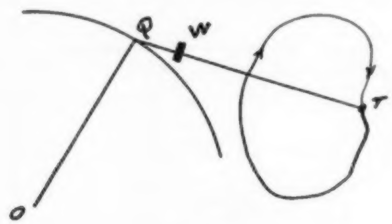



FIG. 8

For areas that are very large, either of two procedures can be followed. A simple but lengthy method is to divide the figure whose area is to be found into sufficiently small parts, then the respective areas are obtained in the ordinary way with the pole outside of each part. Sometimes it is desired to find

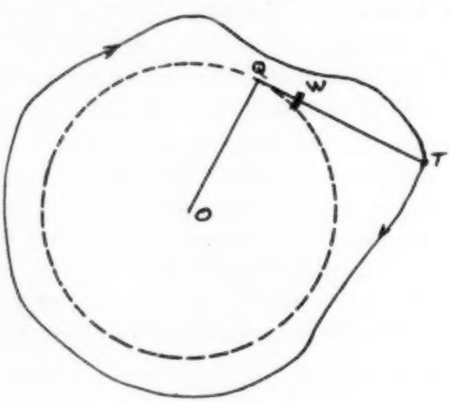



FIG. 9

the areas of a large figure more rapidly than can be done by dividing the figure in parts. The area can be found by placing the pole inside of the figure, as shown in figures 9 and 10. Two important items turn up in placing the pole inside the figure. First, it is seen that as $T$ traces the curve, the arm $QT$ turns

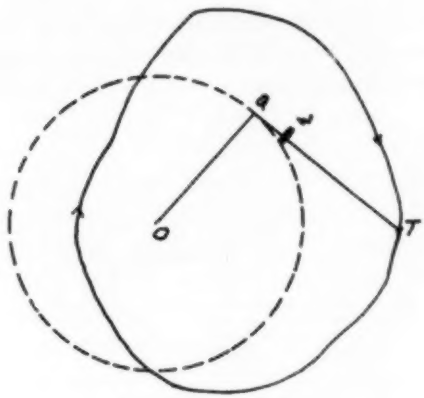



Fig. 10

completely around through an angle of 360°, or $2\pi$ radians. Hence, this time in the formula

$$P = sw + (\tfrac{1}{2}s^2 - sc)\phi,$$

$\phi = 2\pi$ radians, and the area becomes

$$P = sw + (\tfrac{1}{2}s^2 - sc)2\pi.$$

Secondly, according to the Fundamental Proposition, the formula

$$P = sw + (\tfrac{1}{2}s^2 - sc)2\pi$$

would be the difference of the areas of the given closed curves (being traced by $T$), and the circle described by $Q$. Therefore, the area of the circle must be added to have the area of the whole figure, or

$$P = sw + (\tfrac{1}{2}s^2 - sc)2\pi + \pi OQ^2.$$

This may be written

$$P = sw + K$$

where

$$K = (\tfrac{1}{2}s^2 - sc)2\pi + \pi OQ^2.$$

Since $K$ is a constant and depends entirely on the dimensions of the instrument, it is given with the planimeter. Whenever it is necessary to place the pole inside the figure this constant is added to the reading of the scale.

## AN APPLICATION OF THE POLAR PLANIMETER

The planimeter may be used in calculating the indicated horsepower of a steam engine. To do this an indicator diagram

is made, and the area is obtained by using the planimeter. From the area the mean effective pressure in pounds per square inch on the piston can be found.

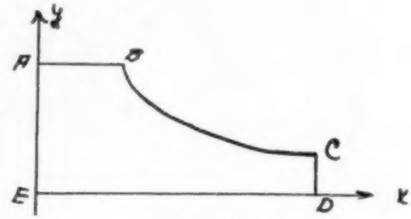



FIG. 11

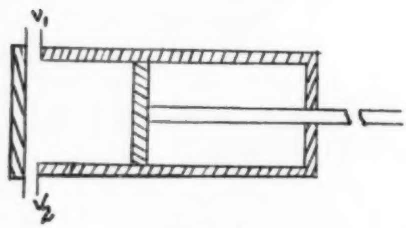
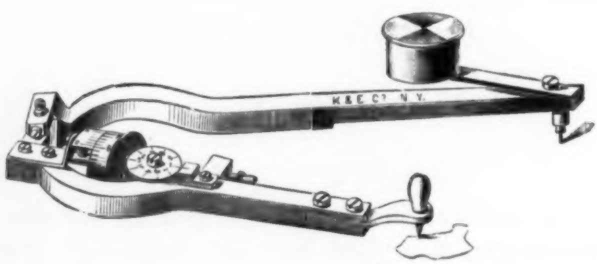



FIG. 12

The indicator diagram, shown in figure 11, is so traced by a pencil that the ordinate represents the pressure of the steam in piston cylinder, while the abscissa gives the distance the piston has moved. Figure 12 is a cross-section of the cylinder with two valves at one end, $V_1$ and $V_2$. While steam is entering through $V_1$, the pressure is greatest and the pencil moves from $A$ to $B$ (figure 11) which is caused by the motion of the piston.



When $V_1$ closes, the pressure is due only to the expansion of the steam already in the cylinder. As the piston moves backward, $V_2$ opens, and the pressure is the lowest, shown in figure 11 by $DE$. Since work equals force times distance, the area of the indicator diagram measures the effective work done. The

explanation just given is for the pressure on one side of the piston. A similar diagram comes from the pressure on the other side, then the horsepower is figured from both diagrams.

### CONCLUSION

After seeing how the mystic motions of the planimeter are performed and an example of its use, it still remains to be told the degree of accuracy in using the planimeter. The polar planimeter will usually give results within one per cent of the truth if care is used. Even change of paper with change of atmosphere conditions makes the scale vary, so that not too high a degree of precision should be expected, nor extreme uniformity of measurements made at different times. However, the accuracy is high enough for most calculations and sometimes more accurate than the drawing of the curve.

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## CONSERVATION EDUCATION LAW IN WISCONSIN, 1935

By Fred Schriever

*Boys' Technical High School, Milwaukee, Wisconsin*

What may prove to be a far reaching measure is the Conservation Education Law passed at the recent session of the Wisconsin State Legislature and signed by the governor on September 10 of this year.

In brief this law provides: (1) that conservation of natural resources shall be taught in every common school and that every high school and vocational school shall offer adequate instruction in the conservation of natural resources; (2) that universities, state teachers' colleges, and county normal schools shall provide adequate instruction in conservation, and that it be required for teachers' certificates in science and social science studies; (3) that the sum of $5,000 be used by the state superintendent of public instruction to prepare and distribute material.

This last provision is very important as it unifies the work of preparing and issuing adequate conservation material. This is very necessary work. It is evident from the reading that the new law was woven into the existing school laws as a part of them and not as something extraneous.

For the sake of reference, the law is quoted as it was passed by the legislature.

*The people of the state of Wisconsin, represented in senate and assembly do enact as follows:*

SECTION 1. Subsection (1) of section 40.22 of the statutes is amended to read: (40.22) (1) Reading, writing, spelling, English grammar and composition, geography, arithmetic, elements of agriculture *and conservation of natural resources*, history and civil government of the United States and of Wisconsin, citizenship and such other branches as the board may determine shall be taught in every common school. All instruction shall be in the English language, except that the board may cause any foreign language to be taught to such pupils as desire it, not to exceed one hour each day.

SECTION 2. Four new subsections are added to section 40.22 of the statutes to read: (40.22) (11) CONSERVATION. Every high school and vocational school shall offer adequate instruction in conservation of natural resources.

(12) TEACHER TRAINING. The governing boards of the university, state teachers' colleges and county normal schools shall provide in their respective institutions adequate instruction in conservation of natural resources.

(13) TEXT MATERIAL. The state superintendent of public instruction and the conservation commission shall cooperate in the preparation of material to be used in the courses offered under subsections (11) and (12) and they shall have power to request the assistance of any teacher or professor in any of the schools of the state in the preparation of such material. They may also make a recommended list of material now in pamphlets or books for guidance of teachers of these courses.

(14) TEACHERS' CERTIFICATES. In granting certificates for the teaching of the courses in science and social studies adequate instruction in the conservation of natural resources shall be required.

SECTION 3. The sum of five thousand dollars is hereby transferred from the general fund to the educational fund, to be used by the superintendent of public instruction in preparing and distributing the materials as provided in subsection (13).

SECTION 4. This act shall take effect September 1, 1935.

The conservation law is now on the books. Further progress will depend upon the teachers themselves and upon the State Department of Public Instruction, so far as Wisconsin conservation education is concerned. If there are any suggestions which members of the Central Association wish to make on the subject, the writer will be pleased to receive them. It is hoped that sound conservation thought and practice will be taught in our schools everywhere in the near future on the ground that it promotes the general welfare.

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Education makes a people easy to lead, but difficult to drive; easy to govern, but impossible to enslave.—Lord Brougham.

# THE STORY OF THE GENE

By Russell W. Cumley
*Austin, Texas*

## I

Modern philosophers and quasi-historical scientists have endeavored to prove that the achievements of modern science were anticipated by the intellectuals of classical antiquity. H. F. Osborn, for example, designates Empedocles as the "father of the Evolution idea." Haeckel extols Anaximander as the prophet of Kant and Laplace on the nebular hypothesis. Such a tendency toward ancestor-worship lends credence to the popular notion that the period of superior intellect lies in the past. And in adopting such an attitude, the philosophers and historians belittle the efforts of those patient individuals of recent times who are responsible for the bulk of modern scientific accomplisoment.

This eulogizing of ancient predecessors has pervaded practically every phase of science history. If one adheres to this practice, Anaximander (611–547 B.C.) must be considered an important figure in the development of the "gene" theory. Anaximander held that life had been created in the mud that once covered the earth; and as the mud dried up, all living things, beginning with the fish-like ancestors of man, came forth. This theory of the origin of life probably grew out of the legends of Anaximander's countrymen, since in these legends, men were said to have been born out of the ground on which they dwelt. By the expedience of their birth, they secured in themselves a natural and divine title to the land. As Anaximander, then, probably is overestimated as a precursor of the modern evolutionist, he may likewise be underestimated as an economist.

The most swaggering humbug of antiquity, Empedocles (*c.*450 B.C.), stated that the various parts of the animal body arose separately. In a wild orgy of flesh and blood, these parts were conjoined at random. Sometimes clumsy monsters were produced that were unable to support themselves or multiply. These monsters were gradually replaced, however, by perfect forms, that were capable of life and of reproduction. The scientific importance of Empedocles' ponderous speculations is uncertain; but his voice should ring down the aisle of time, for he recognized women as the cold-blooded sex.

If there is some question as to the importance of the earlier Greeks in the development of the Evolution theory, the question fails to touch Aristotle. From the geneticist's point of view Aristotle's most outstanding contributions were his experimental demonstrations of a consistent development of life-forms, and his studies in heredity, in which he noted dominance and reversion. Aristotle represented the acme of scientific endeavor previous to the Renaissance. He synthesized the work of his predecessors, and established firmly the foundations of modern biology.

The ancient biologists had no conception of the ultimate vehicles of inheritance. Nevertheless, their philosophical speculations and their efforts at research greatly influenced the later workers. The tragedy of the Middle Ages seems to have been that the Greeks' scientific yet mystical ideas were distorted and perverted, rather than developed. In distorted form, these ideas were accepted *verbatim*, thereby making the most embracing intellect of all time, Aristotle, the very symbol of intellectual decadence. Thomas Aquinas, the medieval demesne-lord of Christian scholasticism, was largely responsible for this inclination toward scientific senility. In his *Summa Theologiae*, the "dumb ox" Aquinas, wove into one fabric the threads of Aristotelianism, Moslem knowledge, and Christian theology. And so well did he blend the dualistic dogma and the scientific aroma of Aristotle's views with the tenets of Paulistic Ecclesiasticism, that for five hundred years an attack upon the doctrines of Aristotle was identical to an assault upon the buttresses of Christianity.

## II

Few men had the courage to rebel against Greek science—after Thomas Aquinas. Even up to the time of Darwin, the misinterpreted concepts of Aristotle were accepted in the field of evolution. Fortunately, however, a small group of persons transcended the current dogma and plunged into original speculation. Among the more important of these was the sixteenth century philosopher, Francis Bacon, out of whose efforts arose the first concrete basis for the studies of genetics, heredity, and eugenics. He pointed out evidences of variation in plants and animals, and showed the analogy that exists between artificially-induced selection and the origination of new creatures in nature.

The sixteenth century Bacon was much ahead of his time. He was succeeded, during the following two hundred years, by

many speculators on heredity and genetics. Oken (1776–1851) was one of the more philosophical of Bacon's successors, and occasionally is thought of as a prophet of modern Evolution. Oken was probably more of a satirist than a scientist. In his theory of the origin of life, he declared that all organisms come from the slime on the bottom of the sea—climaxing this profundity of thought by plucking from his test tube the occult principle: "Love arose out of sea-foam."

The eighteenth and nineteenth century naturalists included Linnaeus, Buffon, Erasmus Darwin, Lamarck and Geoffrey St. Hilaire, all immediate precursors of Darwin. The bulk of their views was not based upon experimental procedure. Most of them held that acquired injuries or changes could be transmitted directly to the offspring. St. Hilaire was the only one among them to state that, in order for this transmission to take place, the changes must be produced in the egg of the animal. All of these naturalists, in formulating their doctrines, were influenced by an Aristotelian or Biblical mysticism—a mysticism extant today in various disguises. The modern geneticist, however, considers microscopic revelations of more scientific value than metaphysical deductions. Hence the twentieth-century spiritual visions regarding genetics generally find nurture among palaeontologists, systematists, legislators, and High-Church schoolmen.

## III

Erroneous ideas are often entertained with regard to Darwin. Uninformed persons believe that Darwin had a knowledge of all fields of biology, beginning with Cambrian palaeontology and coming right on down to modern contraceptive methods. This is not so. Darwin, as a geneticist, was inferior to some of his contemporaries. He held that each cell in the body produces minute particles that are given out into the blood stream. These particles find their way into the ovum or sperm of the individual; and as a result, the characteristics of the parents are transmitted to the offspring. Therefore, if a child loses an arm, his children will be born without one.

Darwin's hypothesis and the views of his immediate predecessors were generally adopted during the last quarter of the nineteenth century. None of these conjectures was founded on experimental data. Weismann did much to overthrow some of the old ideas, although his work also was speculative. He denounced

the notion of the inheritance of acquired characters, and maintained that hereditary variations are caused by the action of outside forces on the protoplasm of the germ cell, rather than upon developed organisms. For postulating such relatively sound principles, Weismann was harassed by farmers, veterinarians, disappointed mothers, and a host of biologists, palaeontologists, and philosophers who were fond of theorizing on inheritances of dinosaurs, musicians, and bob-tailed cats.

Francis Galton, in developing the statistical method in biology, originated Biometry. The statistical method was a decided advance over the old slip-shod fashion of studying. Galton, however, ran amuck trying to measure human traits:—he attempted to predict statistically the per cent of sweet-tempered men that would marry bad-tempered women.

While Europe was gabbing, Mendel was puttering about in his monastery garden in Brunn—crossing peas and founding genetics. In 1900, Mendel's work became known to biologists. That was thirty-six years after he had died—an unknown master. He had discovered that the inheritance of an organism is determined by independent heritable unit characters. In the germ plasm some types of unit characters dominate others and thereby determine the apparent character of the organism by making visible that character. Other characters in the germ plasm are recessive to the dominants and do not appear externally except in the absence of the dominants. Previous to the formation of new individuals, these unit characters segregate as if independent of each other. Ultimately, however, they may reunite to form new combinations, and therefore, an individual of different appearance.

Mendel caused a stir in the field of biology, comparable to that caused by Darwin. Consequently, research, long neglected for fruitless hypothesizing, was taken up with new zeal and fresh hope. The Church, in one fell swoop, had atoned for the Middle Ages.

A year after Mendel's work was discovered, de Vries published the results of fifteen years of research. His work is a monument in the history of genetics. He had learned that new forms of life, called "mutants," may arise abruptly, without transitional forms, regardless of the environment. The parent form remains unchanged, but may frequently give rise to similar deviations. The mutants breed true to form, producing their like. There is no need to go into the criticism which fell upon

de Vries—the foregoing conclusions are sufficient to make any man celebrated. Within the last few years some features of the original mutation theory have been refuted, but as T. H. Morgan, father of American genetics, has pointed out, "the new work has not come from these academic criticisms of de Vries' work, but from a study of the process of mutation itself by methods similar to those inaugurated by de Vries."

After Mendel and de Vries, experimental genetics was elevated to an established science. Bateson and Punnett, in attempting to confirm the Mendelian laws, observed a new factor which Mendel had failed to note. They found that some pairs or sets of characters, when crossed with other sets, do not break up and assort at random. Instead, the parts of a set tend to stay together in later generations. Johannsen, working at the same time, was able to show the difference between temporary fluctuations which are not inherited, and germinal mutations which are inherited. It was Johannsen who gave the term "gene" to the basic units of heredity.

For some years prior to 1900, the germ cell had been considered the unit of life processes, the ultimate thing into which an organism could be resolved. The nucleus of the germ cell was thought to contain the material by which inheritance is accomplished. In this nucleus there are a number of small thread-like structures called "chromosomes." In the process of reproduction an equal number of these chromosomes are transmitted from each parent. Furthermore, on an average, organisms inherit as many traits from one parent as from the other. The obvious conclusion was that the basis of inheritance finally rested in these chromosome structures. At the beginning of the twentieth century, however, no correlation had been made between a particular chromosome in the nucleus and a particular trait in the adult.

A number of workers attacked the problem of revealing the relationship between a single chromosome and a single characteristic of the organism. C. E. McClung, E. B. Wilson, T. H. Montgomery, N. M. Stevens, and W. S. Sutton—all contributed a share to the solution of this problem so important to the later geneticists. They found that a chromosome from one parent connected with the corresponding chromosome from the other parent. The pair thus formed later divided so that each germ cell contained one complete set of chromosomes. This set represented the total inheritance possibilities of the organism.

Furthermore, the resolution of chromosomes into pairs, and the subsequent division, correlated with the segregation of characters as demonstrated by Mendel. Therefore, by the activity of the chromosome, the mechanism of Mendelian inheritance was explained. Finally, the determiners of a single characteristic of the adult could be found within the chromosome itself.

The magnitude of the contributions to genetics during the first half-decade of the present century is overwhelming. The year 1900 brought the Mendelian laws of heredity. De Vries offered the Mutation theory in 1901. In 1903 Johannsen distinguished between germinal mutations and temporary fluctuations. Finally, in the years from 1901 to 1905, the chromosome was recognized as the specific basis of inheritance.

Four fundamentals, a new method of research, and the foundations of a new science—all in five years. In securing a coincidence of biological events of first importance, those five years are unrivaled.

## IV

By 1905, the field of biology had been cleared of the weeds of nonsense. The foundations of modern genetics had been laid. Again the scene of activity shifted. How universal has been the desire to reveal the genes, those finest threads of our making. Greece was the first to try, then England, France, Germany, Austria, Holland. Now, to America.

T. H. Morgan was the new leader. Columbia University was the new laboratory. Morgan drew together the loose ends of biology and tied them into a knot that bore the weight of years. He incorporated into one scheme the fields of taxonomy, cytology, and genetics. The resulting science, what ever its name, was based upon the experimental study of inheritance. Morgan used the vinegar fly, *Drosophila melanogaster*, for his laboratory animal. The reader might take note of the name, for the most recent chapters in the story of the gene have been written with the blood of thirty million of these small arthropods.

Morgan organized a group of scientists. He inspired his associates with his zeal; he impressed them with his skill. Under Morgan's influence, there was probably as much of a cooperative spirit among his associates as every existed in a similar group. C. B. Bridges, A. H. Sturtevant, and H. J. Muller were with Morgan at Columbia. During the first twenty years of this century, these men learned more about the mechanism of hered-

ity than did any other group of men, anywhere else in the world. From their work the "gene theory" was formulated. The paired elements called "genes" were localized in the chromosomes, and were found to determine the characteristics of the individual. These genes occur in a definite linear order and in a definite linkage group within the chromosome. When the germ cell matures and divides, each pair of genes separates. Hence, the resulting germ cells contain but one set of genes. Members of fused pairs of chromosomes were found to assort themselves independently, sometimes twisting about each other like hibernating snakes. Again, these fused pairs may break up and reunite; and a portion of one linkage group may interchange with a portion in a corresponding linkage group—just as two Los Angeleans may swap their wives, or two cowboys their saddles. This type of exchange of parts is known as "crossing-over." The frequency with which this crossing-over takes place gives evidence of the linear order of the portions in each fused chromosome, and of the position of these portions with reference to each other. Numerous other points of the gene theory were clarified or established. Hence, between 1905 and 1927, an enormous amount of fundamental, nonsensational knowledge was accumulated.

After the World War, Muller accepted a position at the University of Texas. Morgan, Sturtevant, and Bridges went to the California Institute of Technology and established there one of the strongest schools of genetics in the world.

Muller had made a good move. In Texas he was associated with T. S. Painter, a cytologist, and J. T. Patterson, an embryologist. A new team was formed in which there existed the diverse qualities essential to the study of genetics.

## V

For many years prior to 1927, the spontaneous production of mutations in the vinegar fly had been studied. Furthermore, numerous workers had tried to induce changes in the genes or in the chromosome complex, which would result in mutations. In attempting to bring about hereditary changes, the geneticists had devised various means of torturing the flies. Some flies were heated. Others were treated with chemicals, e.g., alcohol, arsenic, morphine, quinine, copper sulfate, radium, and ether. Since *Drosophila* is essentially heliotropic, one worker doomed the insect to seventy generations in a dark room. Another bi-

ologist actually forced flies to cohabit with stranger-flies from far-off localities. Finally, ultra-violet rays and x-rays were directed at the little martyrs. No mutations were produced. The results were of interest only to the bereaved families of the deceased flies.

One may ask why the vinegar fly was so exploited. The answer involves a number of facts about the animal: *Drosophila melanogaster* is a most economical beast. If it is left alone, it will mutate, occasionally, on its own initiative. It is blessed with only four pairs of chromosomes. Externally, it reveals a large number of inheritable characters, such as eye color and wing shape. It is an extremely companionable animal, producing a new generation every ten days. Finally, the vinegar fly is content to live and breed within the palatial confines of a milk bottle.

Muller entered the Evolution arena in 1927. There had been Darwin, and Weismann, and Mendel, and one must now add Muller to the list. Muller's genius was born out of elbow-grease. For twenty years he had studied vinegar flies. He had studied them, bred them, murdered them, quartered them, lived with them night and day. In lecturing about them, waving his arms in his discussions concerning them, walking the floor all night because of them, Muller had acquired such an emotional attachment to the genetical eccentricities of these little beasts, that had he failed to produce his results, one would have been more impressed than with his actual achievement.

Muller had developed an exact and delicate fly-breeding technique. Hence, he could intelligibly interpret spontaneous mutations of *Drosophila*. In applying this technique to the artificial production of mutations, Muller made a discovery that his contemporaries had overlooked. In 1927 he announced that mutations had been obtained—both visible mutations and lethal mutations, in the vinegar fly, following treatment with x-rays.

This was a spectacular contribution for geneticists and cytologists. It was anathema for the anti-evolutionists, for it shattered their hyperphysical play-houses, and drained all the psychic juice out of their ecclesiastical squirt-guns.

The palaeontologist finds that Evolution carried on over many millions of years. In the records of geologic time, organic changes occurred so slowly that one type of creature gradually merged into another. Muller sped up this process. By treating the flies with x-rays he increased by one hundred fifty times

the frequency of mutation. In a person's life span, he may examine the fly's genealogy that normally would cover some thousands of years. Aside from producing gene mutations, the x-ray was found to cause chromosomal breaks and translocations. These, too, can give rise to marked changes in the resulting developed animals. Finally, Muller clinched the value of his work in regard to the theory of Evolution, by showing that the induced process of mutation was quite similar to the spontaneous process. Also, different kinds of mutations can be produced by the x-ray, just as different kinds can occur spontaneously.

Of what fundamental importance is Muller's discovery? Flies can mutate by themselves. Hence, the real value of Muller's work does not lie in the mere production of mutations. Furthermore, the experimental corroboration of the Evolution theory is largely of academic importance. Muller, however, placed an effective tool in the hands of the biologist. The possession of this tool is of far greater value than an experimental result or the exposition of a shop-worn theory. The real merit, then, of Muller's work is determined by the utility of the instrument he devised. The world often applauds a brilliant observation, when the finer accomplishment is the means by which the observation was made.

## VI

Within a few months, Muller's work was confirmed by a score of workers. The geneticists at the California Institute of Technology and at the University of Texas led the field in the application and further study of x-ray mutations. Patterson of the Texas laboratory, produced mutations in somatic cells, i.e., in the body cells, as distinguished from the germ cells. The somatic cell mutations give rise to individuals which show a mosaic distribution of characters. This work is of particular interest, for it corroborates, to a certain extent, the hypothesis that cancer is caused by cell mutations. In others of his works Patterson clarified many doubtful and unintelligible features of the mechanism of sex determination. The desirability of combining genetical and embryological knowledge is forcibly revealed by Patterson's work.

For some years doubt had been entertained as to the value of gene mutations. Some workers regarded the mutations as simple losses of gene material rather than physico-chemical changes in the gene structure. This was cleared up by N. W. Timofeeff-

Ressovsky, and Patterson and Muller, working independently. They were able to produce reverse gene mutations. That is, the gene could be made to mutate in opposite directions. Therefore, the possible reconstructive effect of x-radiation was demonstrated.

Muller and Painter of the Texas laboratory, and Dobzhansky and Sturtevant of the California laboratory, independent of each other, produced in great abundance chromosome abnormalities of all sorts. These included simple breaks, translocations, inversions, and deletions of portions of the chromosome. Of course, each type of chromosome abnormality produced a different kind of individual. The wholesale production of monstrosities among vinegar flies is sufficient evidence of the dangers of x-radiation. Recent independent works of Timofeeff-Ressovsky and Muller indicate that the x-ray produces mutations which are organically invisible but which reduce the environmental viability of the animal. Furthermore, these submicroscopic mutations are frequent and may be detected in a large per cent of flies treated with x-rays. Therefore, one should always avoid the x-ray.

J. Schultz and Th. Dobzhansky made another approach to sex-determination by x-radiation. In using unbalanced chromosome complexes they were able to predict, within limits, the relative amounts of femaleness and maleness possessed by the fly.

Following Muller's original contribution in 1927, there have been published more than three hundred articles concerning the production of mutations by x-radiation. Attempts were made to apply the x-ray to a multitude of genetical phenomena. Alongside some positive results were many failures. Only the more distinctive advances in the use of x-radiation are discussed in the foregoing paragraphs.

Chromosomes are small and difficult to see. To resolve them into regions of specific genetic characters is still more difficult. Activity in the field of cytogenetics had been accelerated considerably by the application of the x-ray to the production of gene mutations and chromosome abnormalities. After this initial spurt, however, the science reached a plateau in its development. The chromosome-abnormality work had become highly theoretical. By 1932 cytogenetics was on the decline. Muller had revived genetics in 1927. A new revival was needed in 1932.

Painter, of the University of Texas, led the new revival.

## VII

Considerable data have been accumulated concerning the nature of the chromosomes. The genes are known to lie along the chromosomes. To determine the relationship between a particular adult characteristic and a particular chromosome abnormality, a map of the chromosome is made. This map shows the site of each gene. Therefore, one may correlate the appearance of an adult with the position of a specific gene in the chromosome.

Painter took the guess work out of chromosome-mapping. He discovered the genetical value of the chromosome in the salivary gland of *Drosophila*. Previous to 1932, the chromosomes of the ovarian and neural tissues were used in mapping the genes. Because of the extreme smallness of these chromosomes, the locating of specific gene complexes was never more than theoretical. The salivary gland chromosomes, however, are enormous, being more than one hundred times the size of the ovarian chromosomes. The mapping of genetic areas on these large elements is a matter of certainty. Around these giant salivary particles one may observe certain band patterns. These bands, of which there are many, occur throughout the length of the chromosome in a uniform and definite order. Each of these bands is thought to contain, or to lie beside, or to be in the near vicinity of the gene itself. Painter showed that these large chromosomes could be used in genetical work, just as could the ovarian and neural chromosomes. Then he demonstrated the relation of the bands to the genes, by the use of chromosome abnormalities that had been produced by x-rays, and genetically analyzed by Painter's associates.

When a certain chromosome in the germ cell of the adult is broken up, with the x-ray, that broken chromosome is transmitted to the offspring. In the offspring this broken element will exist in all the cells of the body. Therefore, the abnormalities that are observed in the ovarian chromosomes may likewise be noted in the salivary gland chromosomes. And since these salivary bodies are so large, Painter was able to observe directly the chromosome abnormality that had taken place.

Following any monumental discovery, there are many workers who come forth to criticize and expand the original fact. No fine work is perfect in its incipient stage. Mendel, de Vries, and Muller each placed in the hands of the scientist a piece of valuable equipment. From the use of this equipment, the endur-

ing structures of genetics were erected. Painter has offered the newest tool by which an approach to the lair of the gene may be made.

Painter is followed by a school of salivary gland-chromosome workers in California, Russia, and Texas. These geneticists are elucidating the details which Painter's discovery revealed. In achieving their ends they will exploit the possibilities of the salivary gland chromosomes, and will devise new means of approaching the gene. They hope to determine the nature of the gene itself. Finally, applications of their work will be made to the problems of eugenics and social heredity.

While all this is going on, the vinegar fly resides in a precarious domain.

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## THE INTERESTING NOW

By Mrs. Cecelia M. Whiteman

*Grade 1A-B Greeley School, Minneapolis, Minnesota*

The primary teachers of Minneapolis have become "opportunity conscious." That is, when an unusual thing happens, we look upon it as an opportunity for the learning of new things in the interesting now. This has always been done by some teachers, no doubt, but we are alive to opportunities in greater numbers than before. The freedom we feel with an elastic daily program encourages this.

In our first grade we were about to consider the making of a weather calendar. Having discussed the months of the year, seasons, and the current month, we listed what might be shown on a weather calendar. The sun, clouds, rain, snow, and finally the wind were mentioned. That brought about an interesting talk on winds.

These boys and girls had had a delightful previous experience with a soap bubble party. They had read of a party in their primary readers and at once the children wanted a party. The children's committee put out soap, tables, and pipes on our school grounds on a sunny, breezy day. As for fun, the party was never excelled I am sure.

Our principal, Miss Wallar, came out and said to me, "This lesson has splendid possibilities in science." It had not occurred to me. We were only having fun. However, a suggestion always being appreciated, we began a lesson the following day on soap

bubbles. I said these boys and girls had had a delightful experience with a soap bubble party. These same boys and girls now began to think along new lines of elementary science and the following facts were developed from this lesson.

At the very first question we were forced to go for help to Miss Jennie Hall of the elementary science department because we were dealing with science. We had to make statements that were true. We could not guess nor could we anticipate. We had to find out. The following questions were asked by the children and they do show that they were thinking.

*Question:* When men sell balloons they blow into them with machinery. My father says they blow gas into balloons. Why? Many hands were raised to tell us, and the boys certainly knew that gas is lighter than air.

*Question:* When we blow slowly the bubbles get big. Why do they sometimes burst when we blow fast? With help from the science department we learned that we blew too hard for the elasticity of the soapy water film.

*Question:* What do you blow around the air in bubbles? Dennis said it was soapy water.

*Question:* Can you make bubbles with water that has no soap in it? We put this question on the board and the boys and girls decided to try it out at home. They reported that water needs soap to make it stretch and we began to understand that soapy water is elastic. We also stretched rubber bands until they broke and compared this activity with stretching soapy water until it breaks and there is no bubble.

*Question:* Why do some bubbles go up and some go down? Why do some go so high we can't see them? Billy and Dennis lived next door to each other and their fathers helped them with this question. They said that the lighter the bubbles are the higher they go. The science teacher helped them still further by developing the thought that they are lighter because of the warmer air we put into them.

*Question:* Do bubbles cool off in air? Then what will they do, rise or fall? While we thought we knew the answer, we asked for help and were told to observe the collection of a soapy water drop on the under side of a bubble. We observed variation in size of this drop in different bubbles. Then Billy's twin sisters told us that they had done that and had learned that a bigger drop made a bubble heavier.

*Question:* What makes soap bubbles round? When a little girl

said they were round because they were from a round pipe we proved this was not true by blowing bubbles with toothpaste oblong cartons. We also remembered that milkweed floats and it is not round. Children insisted that bubbles must be round to float as little balloons are round and so are big balloons and Professor Piccard's was. With some outside help we finally concluded the air around the bubble presses it round. The surface tension of the soap film pulls the film into a sphere just as a rubber band returns to its size and shape when no longer stretched.

*Question:* Why were there rainbows? Because they had seen rainbows in the bubbles and only where the sunshine was, they readily concluded that sunshine made the rainbows in the bubbles.

*Question:* Why did bubbles go into the air chute in school? Billy said, without pause, "It is like my mother's Hoover. One of my bubbles went right into my mother's vacuum cleaner. She said it was suction. Then when I took a big spool and blew a bubble, what happened, bet you can't guess. It's just like magic." (No one guessed.) "Well, the bubble went back into the pipe. Is that the new word 'suction'? Then when I put my finger on the end of the spool and gave it a toss, the bubble flew away, and I made a poem for my mother. Want to hear it?" (We certainly did.)

I blew a beautiful bubble
I tossed it hard away,
It floated, and floated, and floated
I went out to play.

Have I seemed to wander far from my talk on winds? It was to show you why those boys and girls were ready for the study of winds. They had begun to think about new things. This interest in soap bubbles spread to other grades and soon it became a building activity. This interesting talk on winds that we had, developed the following lessons:

*The Winds*

Wind is air that is moving.
We name winds from where they come.
So we have north, south, east, and west winds.
Today we have an east wind.
It looks like snow.
Yesterday we had a north wind.
It was a very cold day.
We will watch the winds every day.
Then we will have the winds shown on our weather calendar.

*The Sky*

The sky is cloudy today.
It is dark and gray.
We cannot see the sun.
It is behind the clouds.
The clouds are full of rain.
In cold weather the rain leaves the clouds and turns into snow.
It changes in the air.
On these days we have a cloudy sky.
We will show these days on our weather calendar.
We will use different colors to show the kinds of days.

*Our Calendar*

We made a calendar for December.
It will be a weather calendar.
It will show sunny days, snowy days, and cloudy days.
Then, too, it will show the wind.
We must always put the calendar on a table.
Put the top to the north.
Some one will take it home during our vacation.
Later we will make a story about our December weather.

The day following this story we sat talking about the calendar, and we had a short drill on directions. During the drill some one said, "There is a north wind in this room. I feel a cold wind on my head." We all turned to the north wall. There were no windows or doors but a child saw the cold air chute on the wall. We now had a most interesting discussion that led to ventilation. The children felt the air coming into the room. Where did it go? They went all over the room looking for an outlet. Finally our ever inquisitive Billy found the air chute in the cloakroom.

When we talked with Miss Hall, she said, "You say the air goes up the chute. How can you prove it?" No one knew. She helped with questions until some one reached in and felt the current. The children experimented with tissue paper, watching it go up the chute, and they knew they had proved it. Their lesson the next day was a story they made on ventilation.

*Ventilation*

When we ventilate a room we put fresh air into it.
In our room the cool air comes in through the fresh air chute.
It is cold and heavier than the air in the room.
It goes to the bottom of the room.
It pushes the old air out of the room.
The old air goes up the chute in the cloakroom.
The air moves in a circle in our room.
We ventilate our rooms because fresh air gives us health.

Of course, the next questions were, "Who takes care of these chutes? Where does the fresh air come into the building? Who

looks after it?" When they found out it was their friend, the janitor, they wanted to talk with him and ask him about ventilation. Our visit to him was a very profitable one, and the children then began to think about the janitor and his work. Their story about the visit was made the next day.

*Our Janitor*

We went to visit Mr. Hartman.
He took us to the boiler room.
There are two places to put in coal.
One has a down draft and one has an up draft.
A draft is where the air goes in.
In the upper part of the boiler is the water.
It was half full of water
The water gets so hot it is turned into steam.
It goes to the room in pipes.
No steam is wasted.
After the steam cools off, it turns into water.
This water goes back into the tanks.
The tanks are in the basement, and the water is used all over again.

*Our Ventilation*

Mr. Hartman took us to the fan room.
It was not like the boiler room.
It was very white and clean.
We saw white paint on everything.
We heard a steady sound.
It was like wind.
It was fresh air from outside coming into the fans.
This air is sent along to our rooms.
We saw the shafts it goes through.
It comes into our rooms through the fresh air chutes.
This is how our rooms are ventilated.

And so while we had planned a unit of work on the bakery it never materialized. The work was simply taken out of our hands by a keener interest in things that developed. From the bubble party and from the science lessons which came as a result of this party, the boys and girls began to have new interests and there was no thought given as to what to do now, for each day brought its problems to solve. There were many contributions from the homes as parents had much to offer. From the calendar lesson the children went on to ventilation and as a natural outcome, we just drifted into the unit on the janitor.

Every day in every schoolroom there are valuable opportunities and it is time well spent to stop and consider them. One unit of thinking and reasoning was a natural outcome of an other and while we left a planned program, we had the perfectly natural sequence of lesson after lesson developing from situations in the interesting now.

# CURRENT TRENDS IN JUNIOR HIGH SCHOOL MATHEMATICS

By William L. Schaaf
*Department of Education, Brooklyn College, New York City*

Recently the writer became interested in determining precisely what constituted current curriculum practice with respect to the mathematics taught in the 7th, 8th, and 9th years of the secondary schools in certain parts of the country. To this end, replies to 152 questionnaires were received from mathematics teachers and school superintendents throughout Minnesota, Wisconsin, Michigan, Ohio, Indiana, Illinois, Pennsylvania, New York, New Jersey, Massachusetts and Connecticut. The questions and the results, with an attempted interpretation, are given below.

Question No. 1. As mathematics in the 7th, 8th, and 9th years is taught in your schools, would you characterize it substantially as

(a) general mathematics?
(b) unified mathematics?
(c) "cumulative" mathematics?
(d) conventional grammar school arithmetic in 7th and 8th years, and algebra in the 9th year?
(e) some other way?

| Results. | *a* | *b* | *c* | *d* | *e* |
|---|---|---|---|---|---|
| | 36% | 5% | 7% | 51% | 1% |

Comment. Since (a), (b) and (c) are substantially similar in nature, it is reasonable to infer that in the territory studied the tendency is about equally divided between conventional arithmetic in the 7th and 8th grades, with algebra in the 9th, on the one hand, and some form of unified or general mathematics, on the other hand.

Question No. 2. Does the mathematics in your 7th, 8th, and 9th years include some intuitive, experimental or informal geometry?

| Results. | *Yes* | *No* | *Total* |
|---|---|---|---|
| | 73% | 27% | 100% |

Comment. The findings here would seem to indicate that,

regardless of whether the school is organized on the 8–4 or the 6–3–3 plan, or whether the mathematics of the 7th, 8th, and 9th grades is of a "general" or "traditional" type, nevertheless, in about three out of four instances, *some* intuitive or informal geometry is apparently being taught in one or more of these grades.

QUESTION NO. 3. If the answer to No. 2 is "Yes," is this type of geometry taught in the ——7th year? ——8th year? ——9th year?

| RESULTS.* | *7* | *8* | *9* | *7–8* | *8–9* | *7–8–9* |
|---|---|---|---|---|---|---|
| | 10% | 20% | 6% | 34% | 12% | 18% |

COMMENTS. In those instances where intuitive or informal geometry *is* taught in these grades, it would seem

(1) that relatively little occurs solely in the 9th grade;
(2) that it appears chiefly in the 7th and 8th grades jointly; but
(3) that there is also an appreciable tendency for it to appear in all three grades (almost 20% of the cases reported).

It would therefore seem reasonable to assume that actual practice today shows a somewhat greater than 50% tendency to include some intuitive geometry in the 7th and/or the 8th grade. Putting it another way, intuitive geometry actually appears in either the 7th or 8th grade, or both, in about 70% of *all* schools examined, regardless of the existing type of organization of the mathematics.

QUESTION NO. 4. Do you include any algebra in the 7th or 8th grade? If so, to what extent?

| RESULTS. | *Yes* | *No* |
|---|---|---|
| | 78% | 22% |

COMMENTS. From these results it seems clear that in the majority of schools *some* algebra is taught in the 7th or 8th grade. From the comments on the questionnaires it would appear that the *amount* of this algebra is relatively slight, and is concerned chiefly with formulas, graphs, simple equations, and, in some cases, positive and negative numbers and numerical trigonometry.

QUESTION NO. 5. Is there any arithmetic included in the

* Percentages here are of the total number where intuitive geometry is taught, i.e., excluding those cases left blank in the preceding question.

mathematical instruction in the 9th grade? ——Yes. ——No. If so, to what extent?

| RESULTS. | *Yes* | *No* |
|---|---|---|
| | 54% | 46% |

COMMENTS. At first glance, it might seem surprising that in almost half of the cases recorded there should appear some instruction in arithmetic in the 9th grade. But a closer examination of the remarks on the questionnaires reveals the fact that the bulk of this arithmetic, where it is taught in the 9th grade, consists almost entirely of commercial or vocational arithmetic, and not a review or further drill of earlier arithmetic; also that in most instances, rather than being incidental or supplementary to the algebra, it actually replaces it.

QUESTION NO. 6. Is there any demonstrative geometry taught in the 9th grade mathematics? ——Yes. ——No. If so, to what extent?

| RESULTS. | *Yes* | *No* |
|---|---|---|
| | 22% | 78% |

COMMENTS. The tendency to teach some demonstrative geometry in the 9th grade does not appear to be particularly significant. This inference is based not only upon the percentages above, but also on the typical responses on the questionnaires, the general substance of which was to the effect that "only such geometric material as comes up in connection with teaching formulas." In short, there is no evidence of any considerable trend to include a "unit of demonstrative geometry" toward the end of 9th-grade mathematics.

QUESTION NO. 7. Which of the following do you prefer your mathematics teachers to use?

(a) some standard textbook appropriate to the grade
(b) a representative and adequate workbook
(c) a combination of (a) and (b) above
(d) a so-called "text-and-test" manual
(e) mimeographed material compiled by the teachers or supervisors

| RESULTS. | *a* | *b* | *c* | *d* | *e* | *"Combined Use"* |
|---|---|---|---|---|---|---|
| | 41% | 1% | 41% | 2% | 1% | 14% |

COMMENTS. Since only 1% appear to favor a workbook alone,

since over 40% appear definitely to favor a textbook, and since also 41% favor the joint use of a textbook *and* a workbook, it appears that the textbook in American schools has not as yet been noticeably displaced as a teaching device. The use of "text-and-test" manuals does not seem to have found its way into practice, neither does the tendency to use mimeographed material seem significant. As for the 14% "combined use," this refers of course to combinations other than "a" and "b" above, and apparently indicates a moderate tendency to supplement the use of a textbook with some additional drill, test, or exercise material.

QUESTION NO. 8. Whatever type of textual material you may use, do you prefer?

(a) the conventional expository treatment
(b) a developmental and experimental approach
(c) pupil self-teaching type of material

| RESULTS. | *a* | *b* | *c* | *Combination or Doubtful* |
|---|---|---|---|---|
| | 14% | 57% | 14% | 15% |

COMMENTS. These percentages seem to indicate a desire, at any rate, on the part of about two out of three teachers to use some developmental approach in teaching mathematics in these grades. It would also appear that most teachers are not entirely satisfied with the conventional textbook style, and either modify it by their teaching technique or supplement it with additional material. However, a strictly self-teaching type of textbook or manual does not seem to be particularly favored.

QUESTION NO. 9. Which type of organization of material do you follow?

(a) conventional, or typical syllabus arrangement
(b) psychological, or fundamental learning units

| RESULTS. | *a* | *b* | *Combination or Doubtful* |
|---|---|---|---|
| | 46% | 46% | 8% |

COMMENTS. Here the trend is evenly divided, and it would seem that in actual practice many teachers and administrators have not yet been completely won over to the notion of organizing materials of instruction on the basis of learning units, despite the insistence of educators and psychologists.

QUESTION NO. 10. Which type of development of subject matter do you follow?

(a) that based on arbitrary subject matter subdivisions, e.g., arithmetic, mensuration, experimental geometry, numerical trigonometry, algebra, etc.
(b) that based on a cumulative elaboration of basic mathematical concepts recurring on successive grade levels on higher planes of difficulty

| RESULTS. | *a* | *b* | *Doubtful* |
|---|---|---|---|
| | 56% | 36% | 8% |

COMMENTS. From these results it seems that the inertia of tradition is ever powerful. Or perhaps it is human, even for teachers, to prefer consistently the easier of two alternatives; i.e., since concrete "compartments" such as arithmetic, algebra, trigonometry, etc., are more tangible and convenient, they are preferred to the somewhat less easily managed basic mathematical concepts. Here again educational theory and actual practice would appear to be somewhat inconsistent.

QUESTION No. 11. Which of the several general plans of curriculum organization described below best describes that in actual use in your schools?

| *Grade* | *Plan A* | *Plan B* | *Plan C* | *Plan D* | *Plan E* |
|---|---|---|---|---|---|
| VII | Arith. | Arith. | Arith.<br>Geom. | Arith.<br>Geom. | Arith.<br>Geom.<br>Algebra |
| VIII | Arith. | Arith.<br>Geom. | Arith.<br>Geom. | Arith.<br>Geom.<br>Algebra | Arith.<br>Geom.<br>Algebra |
| IX | Algebra | Algebra | Algebra | Algebra | Algebra<br>Dem. Geom. |

| RESULTS. | *A* | *B* | *C* | *D* | *E* | *Doubtful* |
|---|---|---|---|---|---|---|
| | 39% | 12% | 3% | 25% | 6% | 15% |

COMMENTS. From these results somewhat less than 50% appear to follow the customary tradition in the mathematics of the 7th and 8th grade arithmetic, followed by 9th grade conventional algebra, i.e., plans A and B. On the other hand, only about 35–40% appear to favor some form of unified or general mathematics, which is in general agreement with the findings from Question No. 1.

QUESTION No. 12. Do you believe that the organization of mathematics as taught at present in the 7th, 8th, and 9th grades seems to be

(a) tending more and more in the direction of unified, general, or cumulative mathematics?
(b) reverting gradually to the more traditional or conventional set-up of arithmetic and mensuration in the 7th and 8th grades, and algebra and numerical trigonometry in the 9th?
(c) tending toward a combination of, or a compromise between, types (a) and (b) described above?

| RESULTS. | *a* | *b* | *c* | *Doubtful* |
|---|---|---|---|---|
| | 35% | 16% | 44% | 5% |

COMMENTS. These results obviously indicate a confusion of trends. This seems to be a reasonable inference in the light of the fact that almost half of the responses reveal either a compromise between, or a tendency to combine, both these attitudes toward the organization of mathematics. Leaving out of consideration for the moment (c), the comparison of (a) and (b) might suggest a tendency away from the traditional set-up, but the weight of evidence from (c) tends to offset this conclusion. The question still seems unanswered, or at best, only an approximately evenly divided opinion is certain. This is again quite consistent with the findings from Questions No. 1 and 11.

## SIDELIGHTS FROM PRIVATE CORRESPONDENCE

In addition to the questionnaire described above, private correspondence with public school administrators and teachers in normal schools and teachers colleges scattered over the same territory yielded interesting sidelights on the question under discussion. Some of the more pertinent extracts are here given for the reader's further edification.

### NEW YORK

One normal school official expressed the opinion that "there is a strong tendency to use the unified type of subject matter in the 7th, 8th, and 9th grades, but so far the movement has been confined largely to the cities where the Junior High School influence has been felt. Many Junior High Schools still use the traditional set-up."

Another normal school administrator stated that "in general, we teach a modified arithmetic course in the 7th and 8th grades with algebra in the 9th year. We are obliged to give the algebra course for the benefit of pupils intending to go to college."

From another correspondent, a professor of education in a leading university, the following: "I believe it safe to say at the present time that the mathematics of the Junior High School period are turning more and more in the direction of a unified general course. . . . There seems to be every indication that we shall eventually come to a complete reorganization of our mathematics work, and that the unified course for the Junior High School period will replace entirely the traditional course."

Another nationally known educator from an outstanding university wrote: "In my opinion, the mathematics of the 7th, 8th, and 9th years is tending more and more in the direction of the unified or cumulative type rather than in the direction of the traditional form. It would appear that the Junior High School textbooks are emphasizing more and more the principle of building their materials of instruction around certain important central themes, of which the function concept stands at the head in my judgment. . . . It seems to me that the words 'arithmetic,' 'algebra,' 'geometry,' and 'numerical trigonometry' should be excluded from the vocabulary of the Junior High School mathematics and all the desirable content belonging to these categories should be built around great central themes; if a name is desired for the composite, the word 'mathematics' should be sufficient to cover it."

### PENNSYLVANIA

From correspondence with three state teachers colleges in Pennsylvania, we glean the following evidence, somewhat in the opposite direction. In the words of one writer, "the practice here is to teach traditional arithmetic in the 7th and 8th grades, and formal algebra in the 9th. The consolidated Junior High Schools, and those of the larger cities, tend to the teaching of an integrated course including arithmetic and intuitive geometry in the 7th grade, business arithmetic and algebra in the 8th grade, and algebra and trigonometry in the 9th grade."

Another correspondent states that he thinks "the movement is back toward the more conventional type of work," although he "rather likes the newer plan of giving these Junior High School pupils something along different lines."

An equally candid expression of opinion from a third, to the effect that "the ninth year's work is pretty definitely algebra, but there is considerable attempt, and with much success in spots, to introduce algebraic processes in the lower grades

through the use of the formula in percentage and measurement. So-called intuitive geometry is usually little other than the older mensuration; more use is being made of protractors in experimental work in the geometry, but I note very little tendency toward the introduction of a demonstration. . . . There is a tendency to eliminate much of the formal, but hardly a tendency to break up, to any great extent, the traditional sequence."

MICHIGAN

A public school administrator in one of the leading industrial cities in Michigan suggests that he believes "the seventh and eighth grade mathematics is tending more and more in the direction of a unified, general, or cumulative mathematics rather than reverting to the more conventional or traditional set-up of arithmetic and mensuration in the seventh and eighth grades," adding, however, that he could find "very little evidence that ninth grade mathematics is moving in the direction suggested by many leaders in education and by the National Committee."

In another part of the state, where "all seventh, eighth and ninth grade pupils are in junior high schools," a standard Junior High School mathematics text for the three years was recently abandoned and replaced by a standard arithmetic series for the 7th and 8th grades, and a standard algebra text for the 9th grade.

From one state teachers college we hear that "the present tendency is to some extent away from unification in Junior High School mathematics. I am sure we shall never revert to the set-up as it was before the unification movement started. I am equally sure, however, that we shall not go to the extremes of unification that were indicated a few years ago," and the writer then expresses his belief that no doubt there will evolve a "compromise course."

And this is partly confirmed by another administrator from a state teachers college in a different part of the state, who says: "So far as I can learn, the mathematics taught in the school systems is little different from the traditional curriculum . . . the chief difference between them (the Junior High Schools) and the former arrangement is that now the teaching is mostly departmental. Many of these departmental instructors are the former seventh and eighth grade teachers and it is natural to believe that in most cases they would follow the old order. In my opinion there has been no reversion. In fact, I believe that

very few have tried anything but the traditional curriculum. I hope the tendency is toward the unified or general type, but, if that is the case, the movement is very slow."

OHIO

According to a writer from a well known university in this state, "the larger cities of Ohio have very definitely moved in the direction of a unified, general mathematics course for grades 7, 8, and 9. I think it is true that in these larger cities the work is distributed somewhat as follows:

Grade 7: intuitive geometry, percentage and interest

Grade 8: intuitive geometry, equations, positive and negative numbers, stocks, bonds, corporations and similar phases of business arithmetic.

Grade 9: emphasis on algebra and numerical trigonometry. The schools in the smaller towns will ultimately follow the lead of the larger cities and there is already a tendency to move in that direction."

From another college in the same state our correspondent suggests that "in so far as there is any prevailing tendency I would say that, in our better schools at least, the trend is toward a course such as that outlined below, the algebra and geometry of the seventh and eighth years being taught as an integral part of the arithmetic and as an aid in arithmetical work." He then appends the outline alluded to, as follows:

*Seventh Year:* Review of and further practice on the fundamentals of percentage. Completion of percentage. Practical applications of arithmetic. The formula as a shorthand method of stating the rules of arithmetic. Mensuration. Geometrical designs and constructions. Inductive discovery of such simple geometric propositions as the angle sum of a triangle. Graphs. Scale drawings.

*Eighth Year:* Further applications of arithmetic. Mensuration of solids. The Pythagorean theorem. Formulas. The solution of linear equations in one unknown as an aid in the solution of problems, and in handling formulas.

*Ninth Year:* Algebra with a little numerical trigonometry, enough to solve right triangles.

And from an official in a prominent denominational school system comes the statement that a standard modern text in arithmetic is used in the seventh and eighth grades, followed by a standard text in algebra "introduced in the first year of

high school," and that their idea of Junior High School mathematics would be more along the line of a "unified, general and cumulative type."

### MINNESOTA

From one teachers college in Minnesota comes the information that "the state department has issued a new curriculum for the 7th and 8th grades and has outlined general mathematics for these grades. Some progress has already been made in this direction in the 9th grade." We are also told that one of several difficulties in the way of the new program is the attempt to use "old-fashioned textbooks" in the new course of study.

On the other hand, another teachers college reports that the trend in modern textbooks, in the opinion of this correspondent, has largely solved the question, and "that while 9th grade textbooks have not, as yet, come quite so much in accord, it looks as though we may anticipate a clear agreement as to subject matter for these grades soon."

### WISCONSIN, INDIANA, ILLINOIS

A writer from Wisconsin discloses that there is no state syllabus for Junior High School mathematics, and that they are following the recommendations of the National Committee report.

From a teacher-training institution in Indiana we are advised that "the content of ninth grade mathematics is practically standardized throughout the United States. It consists of algebra with a unit of numerical trigonometry included. The content of the mathematics for grades seven and eight varies. In the smaller high schools throughout the central states the mathematics of these grades is more of the traditional type, but I feel that the tendency is toward general mathematics. In the larger high schools the mathematics of these two grades is more nearly like general mathematics. It is being reorganized from year to year into a well integrated course."

Another colleague, this time from a teachers college in Illinois, thinks somewhat differently, however. He writes: "The results in the public schools have been exceedingly disappointing. Where the Junior High School organization has been adopted, there has usually been no change in the mathematics offered. It has continued to be arithmetic in the 7th and 8th grades, and algebra in the 9th grade. The arithmetic subject

matter, with the exceptions of some additions of the elements of concrete geometry and a little work with equations and formulas, and with the elimination of such topics as cube roots, etc., is much the same as 40 years ago. Progress has been painfully slow, and at present, so far as I can see here in the Middle West, there is little hope for change."

### CONCULSIONS

Summing up the somewhat conflicting evidence here submitted, it would seem that there is no clear-cut trend in current Junior High School mathematics, but that the movement is more or less divided, in some instances leaning toward greater unification, and in the other instances pointing just as definitely toward reversion to traditional practice. This conclusion is confirmed by a correspondent from a teachers college in New England, who points out that "there are tendencies both ways, i.e., both toward general mathematics and toward the conventional arithmetic and algebra, but the balance is favorable to the conventional type of materials." This same informant also adds that while the representative of one of the largest publishers of textbooks feels the movement is toward general mathematics, the representative of another equally influential publisher inclines to the view that the trend is just as definitely the other way.

In concluding, the writer herewith expresses his appreciation of the cooperation of all those who so kindly replied to the questionnaires and other correspondence. It is also hoped that by setting forth the excerpts quoted above no breach of confidence or professional ethics has been unwittingly committed, for it is only in the interest of frankness and sincerity, with a view to further progress, that these expressions of opinion have been gathered together for the benefit of the reader and reprinted here by permission.

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**Soviet synthetic rubber plants have accomplished their scheduled annual program in less than ten months. Last year 11,300 tons of synthetic rubber were obtained from alcohol in the USSR. During ten months of this year, the plants produced 20,000 tons of rubber and should yield another 5,000 tons by the end of the year. The Second Five Year Plan provided for an output of 37,000 tons of synthetic rubber in 1937. However, the industrial process of converting alcohol into rubber has been so successfully mastered that Soviet plants have now been given the task of turning out 40,000 tons of synthetic rubber in 1936.**

# AN EXPERIMENTAL STUDY OF THE RELATIVE VALUES OF A DIRECT AND AN INDIRECT METHOD OF TEACHING STUDY HABITS IN SCIENCE*

BY J. L. NADEN
*St. Anne, Illinois*

## INTRODUCTION

One of the outstanding changes in the metamorphic growth of education in the last quarter of a century is characterized by the shift from the acquisition of knowledge as the goal, to the acquisition of skills and habits. Realizing the utter impossibility of teaching a pupil every fact for which life will call, educational leaders have for some time been advocating the teaching of techniques, scientific attitudes, and efficient habits of study and observation to enable the individual to continue his own education throughout his life. This change has not come about abruptly, nor without considerable hesitation and misgiving. In fact, common practice is still far behind the acceptance of the principle.

The efforts to improve learning by increasing efficiency in the art of studying, group themselves into three major plans or practices: (1) supervised study, (2) how-to-study courses, and (3) directed study. The supervised study epidemic broke out in 1920, and rapidly the country became inoculated with the practice. It was thought that at last a panacea for all educational ills had been found. The germ of the movement underwent, genetically speaking, numerous mutations; for many practices sprang up varying in small and large degrees from the original, but all claiming the same nomenclature. These practices have been summarized very critically by Brownell[1] in an evaluation of the literature on supervised study. He found fourteen types of technique, all bearing the same appellation of "Supervised Study"; and thirty-four merits claimed for the general plan (a veritable educational peroxide with plenty of fizz and foam but benefits chiefly imaginary). He concluded that the merits claimed were invalid, being affected by opinions of enthusiasts.

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* Abstract of Master's Thesis.

[1] Brownell, W. A., *A Study of Supervised Study*, Bulletin No. 26, Bureau of Educational Research, Urbana, Illinois, 1925.

How-to-study courses originated in colleges, but have recently gained some prominence in one form or another in secondary schools as well. At the University of Kansas experimental high school, Cunningham[2] conducted a one-semester course in "How to Study," organized around thirteen study skills and abilities, providing practice in each. Application of these to other subjects was urged and found to be productive of greater interest and better results. Cunningham believed, however, that such training should be given in connection with the other subjects.

The directed study plan of class procedure is one of the most recent developments in the matter of study improvement, and has been accepted with considerable enthusiasm. An outstanding investigation of the worth of this procedure was conducted by Beauchamp,[3] who found that various directed study techniques substantially improved the pupils' knowledge and understanding as shown by objective test scores. In his study Beauchamp used two equated groups of elementary science pupils. In dealing with various units of science material, the pupils of the experimental group were given practice in locating the central idea and important contributing ideas of a paragraph, in formulating questions, in answering thought questions based upon applications of scientific principles, and in reading through an entire unit for the general plan or notion involved. In every case this group proved to be superior to the control group, which was not subjected to these techniques.

These two latter practices, how-to-study courses and directed study, warrant further analysis and comparison. The how-to-study course may or may not include practice in the techniques which it recommends; but the pupil is made conscious that he is to learn and apply those techniques. It might be said, therefore, that the direct method of teaching is used in such a course. Directed study, on the other hand, consists chiefly of practice in certain study techniques during the class period; but the pupil is not necessarily made aware that he is learning study habits. It is, therefore, an indirect method of teaching such habits.

It was this analysis and comparison which suggested the

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[2] Cunningham, Harry A., "Teaching How To Study," *School Review*, XXXIII (May, 1925), pp. 355–60.

[3] Beauchamp, Wilbur L., "A Preliminary Experimental Study of Technique in the Mastery of Subject Matter in Elementary Physical Science," *Supplementary Ed. Monograph* No. 24, Chicago: University of Chicago, January, 1923, pp. 47–87.

further question as to which is the more efficient method of teaching study habits, the direct or the indirect. That question was the germ of the study which the writer undertook.

### PURPOSE OF INVESTIGATION

The purpose of the investigation here reported was to determine experimentally the relative effectiveness of the direct and the indirect methods of teaching study habits in science, as indicated by increase in knowledge and understanding of subject matter. It was not to be a duplication of Beauchamp's study, although similar subject matter was to be involved and equated groups of pupils were to be employed as subjects for the investigation. The purpose of the present investigator was to teach pupils to use habitually, out of class as well as in, the study techniques which Beauchamp employed in directed study only.

### PROCEDURE AND FINDINGS

This investigation was carried on during the school year of 1933–34 in the science department of the Community High School at St. Anne, Illinois. Two classes of ninth-grade general science pupils were equated on the bases of I.Q., reading comprehension, and initial science knowledge. The latter was determined by means of a test prepared by the investigator and consisting of eighty new type test items, composed of twenty each of the completion, multiple response, modified multiple response, and modified true-false types. This test was designed for four chapters of the science textbook, the material to be covered during the eight weeks' experimental period.

TABLE 1

MEAN INITIAL TEST SCORES AND STATISTICAL TREATMENT TO SHOW EQUIVALENCE OF THE GROUPS

| | Group A | Group B | $\frac{D_m}{S.D.D._m}$ |
|---|---|---|---|
| Number of pupils | 20 | 20 | |
| I.Q. | 97.60 | 98.45 | —.27 |
| S.D. | 12.07 | 7.43 | |
| Reading Comprehension | 25.30 | 24.90 | .41 |
| S.D. | 3.21 | 2.93 | |
| Initial Science Score | 32.85 | 31.35 | .66 |
| S.D. | 7.61 | 6.71 | |

That the two groups were statistically equivalent at the beginning of the experimental period is indicated by the fact, as shown in Table 1, that the initial test scores of the two groups were so nearly equal for each of the three bases of equating, that the difference of the means divided by the standard deviation of the difference was less than 1.00.

*Teaching the Study Habits.* A list of twelve desirable study techniques or "tricks of the trade" was made out consisting of three general rules applicable to all subjects, and nine specific devices more applicable to science. This list follows:

*General Habits Essential To Effective Studying*

1. Be prepared with text, manual, notebook, pencil.
2. Begin studying immediately at the appointed time.
3. Concentrate your attention as perfectly as possible upon the subject at hand.

*Specific Habits For Studying Science*

4. Pick out and mark the "guide post" sentence or big idea in each paragraph.
5. Pick out and mark the smaller ideas or facts which help to explain the big idea.
6. Think of examples from everyday life or your own experience to illustrate the principles you are studying. Jot these down in text or notebook.
7. Recall and jot down laboratory experiments and observations to illustrate what you are reading.
8. Solve suggested problems.
9. Underscore or copy scientific terms, definitions, numbers, names of scientists, etc.
10. Refer to previous topics in your textbook to help you solve problems and answer questions.
11. Use glossary and index of text and reference books.
12. Use the dictionary and encyclopedia for terms and processes which are unfamiliar.

These were presented to the pupils at the rate of one or two per day on an average of two days per week, as part of the regular class program, and in connection with the subject matter being covered at that time. An introduction was carefully planned for the sake of motivation for each of the devices, and was employed with both classes. The pupils were given practice in the use of the devices immediately following presentation. As an illustration of this technique, the following introduction was used for the first two of the specific devices for studying science, namely, to pick out and mark the "guide post" sentence of each paragraph and to pick out the smaller ideas which help to explain the big idea:

Everyone likes to travel. Suppose you are starting on a trip to a part of the country which you have never visited before. Imagine, for example, that you are going south and that on the first lap of your journey Danville will be the first large town or city that you will encounter. As you leave familiar surroundings and enter strange territory, what do you begin to do? (Someone suggests refering to a map; another, looking for signs.) That's right; you look for sign posts directing you to the big city. The sign post doesn't tell you the kind of territory through which you will pass, nor the nature of the road, nor the kind of bridges you will cross, nor the number of small towns you will encounter. It merely gives you the one all important fact that this is the way to Danville. After you are satisfied that you are on the right road, then you give your attention to the smaller details, and you enjoy the trip.

Now your journey through science is very much the same. For the most part, you are traveling in strange country. Each paragraph or page is a lap in your journey. What's the reasonable thing to do? Correct; look for signs. A paragraph ordinarily has a sentence which expresses the big, important idea. We might call it the "guide post" sentence. After you have found it, then you can pick out the smaller ideas and details which help to explain it. Thus the new territory becomes familiar.

Now let's take a little trip into strange territory and see how our trick of the trade works. Refer to your textbooks to page 84 and the paragraph entitled "Kindling Temperature." Read the paragraph to yourself quite rapidly, but keep on the lookout for the "sign post," the one sentence which gives you the big idea of the entire paragraph. You may begin to read.

After a few minutes had passed, hands began to go up. Time was called and their findings were checked. They were then instructed to read the paragraph again for the contributing facts and details. This was done for several paragraphs.

Up to this point, the technique was the same for both groups; that is, the introduction of the study devices and the practice in their application were identical for both classes. Here, however, the methods branched. When this point was reached for Group B, the direct method group, the pupils were asked to write down statements of the devices. For the sake of definiteness and uniformity, these were dictated to them. They were then told to learn these devices and make a habit of applying them in their daily study.

For Group A, the indirect method group, this latter part was totally eliminated. They were not told to learn nor to use these devices. They were not even asked to write them down. Following the introduction and practice application of the techniques, the pupils were left to draw their own conclusions.

The other study habits were presented in similar manner. For each habit, the same introduction was employed for both groups up to the point mentioned in the previous paragraphs where the two methods separated. This presentation occupied

about four weeks. During the remaining four weeks of the experimental period, a certain amount of time was devoted each week in Group B to practice and drill on the study devices, to fix them in the minds of the pupils. In Group A a corresponding amount of time was devoted to the use of the devices, but each time brought up indirectly and incorporated into the class discussion as a casual suggestion or a "good idea" for dealing with science material. *Never* was the class drilled on the list of study habits. In brief, the two groups were treated identically alike in all respects except one: Group B was made consciously aware that they were to learn and use certain techniques of study; Group A was not.

At the end of the experimental period, the original subject matter test was again administered. The mean scores and the mean improvement over the initial scores were calculated and tabulated for the purposes of comparative analysis, as shown in Table 2. It can be seen that Group A was somewhat in advance of Group B in respect to science knowledge. The difference of the mean divided by the standard deviation of the difference, being greater than 1.00, indicated a possible statistical significance in favor of Group A. This in turn implied a possible superiority of the indirect method over the direct method of teaching study habits.

TABLE 2

MEAN SCIENCE KNOWLEDGE SCORE AND STATISTICAL TREATMENT

| | Group A | Group B | $\frac{D_m}{S.D.D._m}$ |
|---|---|---|---|
| Initial Science Knowledge Score | 32.85 | 31.35 | .66 |
| S.D. from the Mean | 7.61 | 6.71 | |
| Final Science Knowledge Score | 57.00 | 53.20 | 1.39 |
| S.D. from the Mean | 8.47 | 8.85 | |
| Improvement of Science Score | 24.15 | 21.95 | .99 |
| S.D. from the Mean | 8.17 | 5.67 | |

In an effort to determine the extent to which the study habits were being used, and the correlation between their use and subject matter scores, it was decided to record from the students' textbooks and notebooks all indications of the use of study habits for the duration of the experiment. Accordingly, some time before the experiment began, the investigator personally inspected all textbooks, page by page; that is, the chapters

to be covered during the experimental period. By erasing all hand writing, notes, and data that had been previously placed there, the second-hand books were made "as good as new." The new texts were also checked.

At the end of the eight weeks the texts were again inspected, as were also the laboratory manuals and notebooks. All indications of the use of study habits were recorded and tabulated. It was found that Group B, the direct method group, had indicated the use of study devices many more times than had Group A. But at the same time, Group B had made a lower mean score on the final subject matter test, as shown in the previous table. This seemingly paradoxical situation may have been due to the direction of the pupils' attention. The pupils taught by the direct method, Group B, had been consciously aware that they were expected to learn and to use the study techniques. In an effort to do so, their attention was probably more or less diverted from the real subject matter being studied. On the other hand, those taught by the indirect method, Group A, were not conscious of any obligation to use the devices; but those devices which had been learned incidentally had become habitual, and were therefore used effectively.

To obtain a more exact relationship between the number of study devices indicated and the improvement in science knowledge score, the Pearson product-moment correlation coefficient was determined, and found to be .56 for Group A, and .20 for Group B. The higher positive correlation for Group A is another point in favor of the indirect method of presenting study habits.

## CONCLUSION

In so far as this study is indicative, it seems justifiable to conclude that for immediate recall of subject matter, there is a possible superiority of the indirect method over the direct method of teaching study habits in science.

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# CORRECTING ERRORS IN THE HISTORIES OF MATHEMATICS[1]

BY G. A. MILLER
*University of Illinois, Urbana, Illinois*

Recently a well known Belgian mathematician, M. Lecat, published a small but unique volume entitled *Erreurs de Mathématiciens des origines à nos jours* (1935). In the preface thereof he states that with some exceptions historical errors are not included in his book and that one could make a large volume with those only which have been found in M. Cantor's remarkable *Vorlesungen über Geschichte der Mathematik*, thus emphasizing the fact that many errors appear in our histories of mathematics. He aimed to include only errors in logic which are still somewhat current but he did not follow this aim completely because some other errors have a peculiar interest in fixing the physiognomy of certain writers. The book contains the names of more than 350 authors of errors, including the well known names of N. H. Abel, A. L. Cauchy, A. Cayley, R. Descartes. L. Euler, P. de Fermat, C. F. Gauss, C. Hermite, J. L. Lagrange, G. W. Leibniz, I. Newton, H. Poincaré, and J. J. Sylvester.

The very high regard for the works of these men on the part of the mathematicians of the present day is definite proof of the fact that the discovery of an error in the work of a mathematician does not necessarily remove his name from the list of those who made the most valuable contributions towards the advancement of our subject. It should be noted that errors are of widely different grades of discreditability. In working in a new field many mathematicians of the highest caliber have sometimes proceeded too rapidly to make certain that all their conclusions are valid. The errors thus resulting reflect comparatively little discredit on their authors. In the preface to his *Vorlesungen über Geschichte der antiken mathematischen Wissenschaften*, volume 1 (1934), O. Neugebauer remarks that it is clear that in a so newly opened field as that of the pre-Grecian mathematics the future is destined to complete and correct much that is said here. It is more important to induce others to extend and improve this work than to conceal errors in views by cautious silence. The cultivation of the ability to conceal ignorance should be avoided in teaching as well as in writing.

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[1] Read before the Indianapolis Mathematical Club, April 29, 1935.

As an instance of an error of a widely different character we cite the statement that J. Farrar (1779–1853), of Harvard College "did much for elementary mathematics in this country through his translations (1818–1825) of the works of Euler, Lacroix, Legendre, and Bézout, and through his publication of a number of textbooks."[2] It is easy to see that an uninformed reader is likely to obtain a very erroneous impression from this quotation, if one thinks of the enormous extent of these works and of the fact that after several unsuccessful attempts to publish the works of L. Euler (1707–1783) alone the project was finally undertaken in 1909 by the Swiss Society of Naturalists aided by a number of learned academies in various countries and by an international society organized especially for this purpose. It is obviously also very misleading as regards the lack of good library facilities in our country at the time, and the very elementary character of the writings of J. Farrar. Errors whose implications are so misleading and which could so easily have been avoided seem to me to constitute one extreme in the hierarchy of mathematical historical errors, even if the term "the works" is not assumed to mean all the works in question.

One of the greatest obstacles to the progress of mathematics has always been the disinclination to correct current errors. In fact, the correction of errors is a fundamental feature of the development of our subject and is most noticeable in times of greatest progress. It is a marvelous fact that in the long period of pre-Grecian mathematical development there does not appear a single instance of a carefully thought out plan to secure the determination of the ratio between the circumference and the diameter of a circle to any desired degree of approximation. The fact that in the 2000 year period of the recently discovered developments of Babylonian mathematics this ratio was so commonly assumed to be 3 seems at first almost incredible even if some evidences seem to point to other approximations. The much closer approximation 256/81 which was sometimes used by the ancient Egyptians could also have been readily proved to be inexact although no evidence exists pointing to a knowledge of this fact on the part of a single pre-Grecian mathematician. The fact to be emphasized is that rough approximations seem to have been regarded as accurate during long periods

[2] *A History of Mathematics in America before 1930*, by David Eugene Smith and Jekuthiel Ginsburg, 1934, p. 96.

of time although their inaccuracy could easily have been established.

The Biblical admonition "prove all things" is even yet too often unheeded in mathematical work and seems to have seldom been followed in ancient times. Such proofs naturally give rise frequently to the discovery of errors and to efforts to correct them. In many cases the corrections have to be corrected successively before a satisfactory solution is found. In the book cited at the opening of this article its author states, in particular, that most of the investigations in the calculus of variation before 1870 rest on methods which are inexact or insufficient. In the article entitled "Sur les groupes finis discontinus" in the well known *Encyclopédie des Sciences Mathématiques*, volume 1 (1909), page 563, it is stated that enumerations of groups of low degrees were made many times, each author generally verifying and often correcting the results of his predecessors before completing them. Similar remarks apply to other new fields in mathematics.

The history of mathematics is especially subject to errors for various reasons, including the following: Many writers thereon have not been well informed mathematicians and have not acquainted themselves thoroughly with the nature of the subjects whose history they endeavored to present. In the preface to his once popular and still well known *Histoire des Mathématiques* J. E. Montucla (1725–1799) stated that his first object in preparing himself to write this work was to secure a sufficiently profound knowledge of all parts of mathematics without which such a work would be void of matter and so full of errors as to provoke laughter on the part of the mathematicians. He was especially interested in giving a distinct idea and the true principles of all the theories considered in his treatise. It must be admitted that if he had lived a century later he would have found it much more difficult to cover thoroughly such a wide field but the idea that a subject must be fully understood before a satisfactory history thereof can be written seems to be sound although it has not always been adopted by writers on the history of mathematics.

In the work by O. Neugebauer to which we referred above the author confined himself almost entirely to the works of the ancient Babylonians and the ancient Egyptians in dealing with the history of pre-Grecian mathematics. On page 208 he gives the following reason for this course of procedure: The history of

Indian mathematics is today still in a distrustful condition. This is not so much due to a lack of workers in this field as to the fact that almost no source material has as yet been edited which is in an unquestionable form. All that we know rests therefore on the arbitrary selections from extant fragments. A scientific investigation of this extensive material can only follow when a systematic unlocking of the sources has been made. The same is true, perhaps in a still higher degree, as regards Chinese mathematics and astronomy. It should be noted that more than 90 per cent of what appears in our histories of mathematics in regard to Chinese Mathematics is not reliable.

Among the general histories of mathematics in the English language the one by D. E. Smith seems to pay most attention to the mathematics of the ancient Chinese. This is probably due to the fact that in this work legends are interspersed somewhat freely with more serious matters, apparently with a view to holding the interest of the reader. In particular, we find on page 31 of volume 1 that tradition states that a Chinese prince "had a wrist like a swivel on which his hand could turn completely round—an odd fiction for those who are interested in stories of mathematicians." In the review of this volume it is stated by G. Sarton that "the inclusion of fanciful portraits (for example, of Plato and Fibonacci) seems to me a serious mistake for which I can find no justification."[3] It should be emphasized that there is a wide difference between pointing out errors and suggesting possible improvements, and the condemning of a book as a whole. Sometimes merits of the highest order are associated with defects which should be corrected in the interests of the reader and of the progress of knowledge relating to the subject in question.

It may be noted that as regards mathematical history and the closely related subject of mathematical reviews the material which has been published in the German language exceeds that of any other language. The journal entitled *Jahrbuch über die Fortschritte der Mathematik* (1871– ) was for sixty years the outstanding mathematical review. In recent years another such review, mostly in German, was started under the title *Zentralblatt für Mathematik und ihre Grenzgebiete* (1931– ). These reviews may be regarded as current mathematical history and they often include the noting of errors relating to the subjects

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[3] *Isis*, vol. 6 (1924), p. 443.

treated. Here, as elsewhere, it is true that these corrections are often in need of further corrections but they have doubtless been very useful not only in extending our knowledge but also in promoting greater care on the part of authors since these know that their publications will probably be critically examined soon after their appearance by those whose findings will be widely read.

Since Vera Sanford's *Short history of mathematics* is widely used in our schools as a textbook it may be desirable to direct attention here to a few statements contained therein which teachers should consider also from a different point of view. For instance, the closing sentence of the first paragraph seems to imply that all pure mathematics is philosophy. If this is true it may be asked why this subject is not taught in the philosophy departments of our universities. The statement that "our knowledge of the mathematics of Babylonia is based on actual business documents," which appears near the beginning of this book, might be used as an illustration of the recent changes of views relating to the history of ancient mathematics. Only a few years ago this quotation represented fairly well the known facts but today it is out of date as O. Neugebauer proved in the work to which we referred above. A large part of the recently discovered Babylonian mathematics, such as their solutions of quadratic, cubic, and biquadratic equations, has no direct connection with business transactions, being pure mathematics in the modern sense of this term.

The growth of our knowledge of the history of mathematics was greatly promoted by the 2000 corrections which appeared in the *Bibliotheca Mathematica* and relate to the work of M. Cantor noted in the first paragraph. The student of the history of mathematics who takes the trouble to consider these corrections naturally finds that the usefulness of M. Cantor's extensive work has been greatly promoted by them, especially since they inspire caution as regards generalizations in the history of our subject. While the corrections of errors relating to other histories of mathematics have been less conspicuous they have been of great value and will doubtless continue to be of great value to those who seek a thorough insight into the development of mathematical ideas during the past and their growing effectiveness in our modern civilization.

In view of the fact that Webster's *New International Dictionary* is widely used in the schools of our country it may be de-

sirable to refer here in closing to several statements contained in the recent greatly enlarged second edition (1935) which relate to the history of elementary mathematics. Under the term "algebra" there appears the following striking remark: "The essential difference between arithmetic and algebra is that the former deals with concrete quantities while the latter deals with symbols whose values may be any out of a given number field." A very important element of the history of elementary mathematics is the study of the question when abstract mathematical concepts came into common use. One of the earliest of these is that of abstract numbers such as appear in our common multiplication tables and are usually treated in the elements of arithmetic. It is therefore difficult to explain and impossible to justify the fact that a characteristic feature of arithmetic is here said to be due to the assumption that it deals with concrete quantities. It would be difficult to prove that algebra is more abstract than arithmetic and the relatively large amount of abstract mathematics in ancient times is a fundamental fact in the history of our subject.

Under the term "logarithm" it is stated that "tables of natural logarithms were published by John Speidel (London, (1619)." The tables in question did not appear in the edition of 1619 of John Speidel's *New Logarithms* but in later editions, beginning with 1622. What is more important is that it is questionable whether these tables can be properly called "tables of natural logarithms" since they were not computed with respect to the base $e$, whose value was then unknown. They were merely slight modifications of the tables computed somewhat earlier by John Napier and hence they were only approximately equal to tables of natural logarithms.

Under the term "Ludolph's number" it is said that Ludolph van Ceulen (1540–1610) computed the value of the ratio of the circumference to the diameter of a circle. As this ratio is transcendental it can not be completely computed in the sense of expressing it as a decimal. Ludolph van Ceulen computed only three more decimal places than had been known earlier and much closer approximations were computed later. Hence the term "Ludolph's number" is a misnomer. Under the letter $x$ a theory is given as regards its original use which has been discarded by the best writers on the history of elementary mathematics, such as J. Tropfke. Cf. *Geschichte der Elementar-Mathematik*, volume 2 (1933), pages 55–59. These few facts should in-

spire caution as regards the use of this valuable dictionary with respect to mathematical terms. It should be added that this second edition is much more useful to the student of mathematics than the earlier ones notwithstanding desirable corrections.

## ELECTRIC CHARGES ON STRETCHED RUBBER BANDS

*By* J. J. Coop, *Indiana University, Bloomington, Indiana*

It was observed by the author more than two years ago that when a stretched rubber band was plucked near the grid input terminal of an audio amplifier the note was reproduced in the speaker. Using an amplifier with a voltage amplification of about 50,000 the note could be heard from the speaker even when the rubber band was plucked nearly a meter distant from the grid terminal.

This effect almost, if not entirely, disappears when a neutral rubber band is started vibrating by jerking. If the neutral rubber band then be rubbed against some object the note will be heard in the speaker even though the band be set into vibration by jerking. These observations tend to show that the effect is produced by a charge on the rubber band and that the charge is produced by friction and not by stretching as stated by Larson.[1]

A further study was made using electroscopes. It was found that when a neutral rubber band was drawn against the knob of an electroscope the electroscope received a positive charge while the rubber band acquired a negative charge. When rubbed against the knob of a second electroscope the rubber band gave to this electroscope its negative charge. This charge can be neutralized and reversed by further rubbing. In all cases where a stretched rubber band was rubbed against such substances as wood, glass, iron, brass, or copper it received a negative charge. By contact this negative charge may be given to an electroscope. Stretching a neutral rubber band near the knob of an electroscope had very little, if any, effect. A neutral band did not attract small bits of paper when stretched. These experiments show that friction instead of stretching is the source of the charge on stretched rubber membranes.

[1] Larson, K. G. *Rev. Sci. Inst.* 6, 242 (1935).

# PROBLEM DEPARTMENT

Conducted by G. H. Jamison
*State Teachers College, Kirksville, Mo.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor* should have the author's name introducing the problem or solution *as on the following pages.*

*The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.*

## SOLUTIONS AND PROBLEMS

**Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.**

**1. Drawings in India ink should be on a separate page from the solution.**

**2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.**

**3. In general when several solutions are correct, the one submitted in the best form will be used.**

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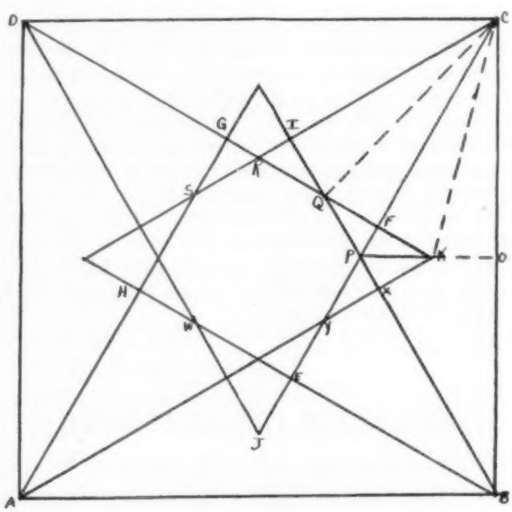
## LATE SOLUTIONS

**1395–8.** *Charles W. Trigg.*

EDITOR'S NOTE: In the first part of the statement of Problem 1410 (1 +3K) should be (1 +3x).

**1400.** *Proposed by Charles W. Trigg, Los Angeles.*

On each side of a square, equilateral triangles are constructed so as to fall within the square. A portion of the area will be included in all of the triangles, part of it will be in three only, part in two only, and some in only one of the triangles. Determine the portion of the area of the square which falls in each category.




The areas to be determined are:

1. The portion of the square in one triangle only which is 4 (Area $ABEJW$) $=16\Delta KCF$.
2. The portion of the square in two triangle only which is 4 (Area $BXYE$ $+$Area $KFPX$) $\equiv 4[2\Delta KCF + 2\Delta PKF]$.
3. The portion of the square in three triangles only which is 4 (Area $PFQ$ $+$Area $QIR$).
4. The portion of the square in four triangles which is Square $FGHE$ $-4\Delta SRG$.

All areas can be expressed in terms of a square $FGHE$ and/or $\Delta PKF$, $\Delta KCF$ as follows:

$$\triangle KCO = \triangle KCF = \triangle QCF = \triangle QCI \tag{5}$$

$$\triangle SRG = \triangle RQI = \triangle PQF = \triangle PKF. \tag{6}$$

To compute areas of $\Delta PKF$, $\Delta KCF$ and Square $FGHE$
Let side of Square $ABCD = S$.

$$\triangle DCF \text{ is 30-60 rt. } \triangle \text{ and } DF = \frac{s}{2}\sqrt{3},\ DC = S,\ FC = \frac{s}{2}.$$

$$\text{Area } \triangle DCF = \frac{1}{2}\cdot\frac{s^2}{4}\sqrt{3}. \tag{7}$$

$$\text{Area of square, } FGHE = \text{Area of } ABCD - 4\triangle DCF$$
$$= s^2 - 4\cdot\frac{1}{2}\cdot\frac{s^2}{4}\sqrt{3} = \frac{s^2}{2}(2-\sqrt{3})$$

$\triangle PKF$ is 30–60 rt. $\triangle$; $KF = DK - DF$ where $DK = s$ and

$$DF \text{ (above)} = \frac{s}{2}\sqrt{3}, \qquad KF = s - \frac{s}{2}\sqrt{3} = \frac{s}{2}(2-\sqrt{3}).$$

$$\text{Also } KF = \frac{PK}{2}\sqrt{3} \text{ or } \frac{s}{2}(2-\sqrt{3}) = \frac{PK}{2}\sqrt{3}, \quad PK = \frac{s}{\sqrt{3}}(2-\sqrt{3}).$$

$$\text{Area } \triangle PKF = \frac{1}{2}\cdot\frac{PK^2}{4}\sqrt{3}$$
$$= \frac{s^2}{24}(7-4\sqrt{3})\sqrt{3} = \frac{s^2}{24}(7\sqrt{3}-12) \tag{8}$$

$$\triangle KCF \text{ is a rt. } \triangle \cdot CF \text{ (above)} = \frac{s}{2}, \quad KF \text{ (above)} = \frac{s}{2}(2-\sqrt{3})$$

$$\text{Area } \triangle KCF = \frac{s^2}{8}(2-\sqrt{3}). \tag{9}$$

To evaluate: (1), viz, Portion in One $\Delta$

$$\text{Area} = 16\triangle KCF, \text{ (from (9))}, = 16\cdot\frac{s^2}{8}(2-\sqrt{3}) = 2s^2(2-\sqrt{3}).$$

(2), viz., Portion in two triangles

$$\text{Area} = 4[2\triangle KCF + 2\triangle PKF] = 8\left[\frac{s^2}{8}(2-\sqrt{3}) + \frac{s^2}{24}(7\sqrt{3}-12)\right]$$
$$= \frac{s^2}{3}(6-3\sqrt{3}+7\sqrt{3}-12) = \frac{2s^2}{3}(2\sqrt{3}-3).$$

(3), viz., Portion in three triangles. From (6),

$$4\,(\text{Area } \triangle PFQ + \triangle QIR) = 8\triangle PFQ$$
$$= 8\cdot\frac{s^2}{24}(7\sqrt{3}-12)$$
$$= \frac{s^2}{3}(7\sqrt{3}-12).$$

(4), viz., Portion in four triangles.

Square $FGHE-4\Delta PKF$. From (7) & (8)

$$=\frac{s^2}{2}(2-\sqrt{3})-4\cdot\frac{s^2}{24}(7\sqrt{3}-12)$$

$$=\frac{s^2}{6}(18-10\sqrt{3})$$

$$=\frac{s^2}{3}(9-5\sqrt{3}).$$

Solutions were also offered by Maxwell Reade, W. R. Smith, W. E. Buker, and Martin Bowman, Philadelphia.

**1401.** *Proposed by Charles C. D'Amico, Albion, N.Y.*

A water glass containing water is tilted so that water extends from the top of the glass to a diameter of the base. Find the value of the water if the glass has an altitude of $h$ and diameter of $2r$.

*Solution by Charles W. Trigg, Cumnock College, Los Angeles*

Assuming that the glass is a right circular cylinder and that the dimensions are inside dimensions, let the base of the glass fall in the $XY$-plane with the diameter along the $Y$-axis and the center at the origin. Then it is required to find the volume included by the cylinder, $x^2+y^2=r^2$; the plane, $xh=rz$; and the plane $z=0$. This volume is

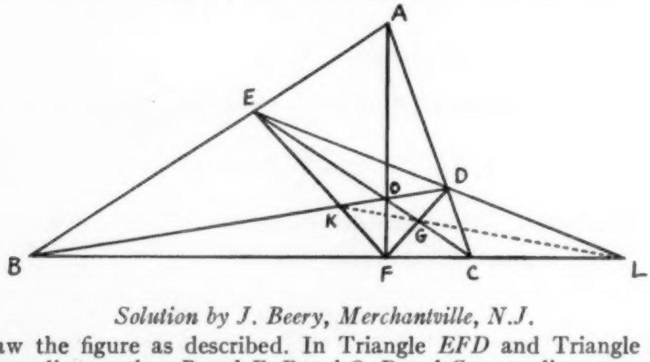
$$2\int_0^r\int_0^{\sqrt{r^2-x^2}}\int_0^{hx/r}dz\,dy\,dx=\frac{2h}{r}\int_0^r x\sqrt{r^2-x^2}\,dx$$

$$=\frac{2h}{r}\left[-\frac{(r^2-x^2)^{3/2}}{3}\right]_0^r=\frac{2hr^2}{3}.$$

Solutions were also offered by Maxwell Reade, Brooklyn, W. R. Smith, Chicago, Daniel Finkel, Brooklyn, A. R. Haynes, Tacoma, W. E. Buker, Leetsdale, Pennsylvania, and Charles C. D'Amico, Albion, N.Y.

**1402.** *Proposed by Rose Kowaloff and Maxwell Reade, Brooklyn, N.Y.*

In Triangle $ABC$, $AF$ is an altitude. Through a point 0, on $AF$, $BD$ and $CE$ are drawn, $D$ and $E$ being on $CA$ and $BA$ respectively. $DE$ meets $BC$ at $L$. $BD$ meets $EF$ at $K$. $EC$ meets $FD$ at $G$. Prove $L$, $K$, $G$ are Collinear.




*Solution by J. Beery, Merchantville, N.J.*

Draw the figure as described. In Triangle $EFD$ and Triangle $BOC$, corresponding vertices $B$ and $E$, $F$ and $O$, $D$ and $C$ are on lines concurrent at $A$, hence the intersections of the corresponding sides $ED$ and $BC$ at $L$, $FD$ and $OC$ at $G$, $EF$ and $OB$ at $K$ are collinear by Desargues theorem:

If the lines joining corresponding vertices of the two triangles are concurrent, the corresponding sides intersect in collinear points.

Solutions were also offered by Aaron Buchman, Buffalo, David Gordon, Woodbine, N.J., Charles C. D'Amico, Albion, N.Y., Isadore Chertoff, Bayonne, N.J., A. R. Haynes, Tacoma, and Rose Kowaloff and Maxwell Reade, Brooklyn.

**1403.** *Proposed by Dewey C. Duncan, University of California.*

If $D$ is the orthocenter of $\Delta ABC$, then any three of the four points $A$, $B$, $C$, $D$ may be taken as the vertices of a triangle and the fourth point will be the orthocenter.

*Solution by W. E. Buker, Leetsdale, Pa.*

The orthocenter is the point at which the altitudes are concurrent. $AD$, $BD$, $CD$ are perpendicular to $BC$, $AC$, $AB$, respectively. In $\Delta BCD$, $AD$ is the altitude through $D$, $AC$ is the altitude through $C$, and $AV$ is the altitude through $B$. They are obviously concurrent at $A$ which point is the orthocenter of $BCD$. Similarly for $\Delta ACD$ and $ABD$.

Solutions also were offered by David Gordon, Norfolk, Virginia, Charles C. D'Amico, Albion, N.Y., A. R. Haynes, Tacoma, Charles W. Trigg, Los Angeles, and the proposer, Dewey C. Duncan, University of California.

**1404.** *Proposed by H. C. Torreyson, Chicago, Illinois.*

Find $x$, $y$ and $k$, such that $x$ and $y$ will be positive integers and $k$ a minimum in the equations:

$$1057x-411y=212$$
$$x+y=k.$$

*Solution by David Gordon, Norfolk, Virginia.*

From the first equation, it follows that

$$y=\frac{1057x-212}{411}=3x-1+\frac{199-176x}{411}\cdot$$

Let $199-176x=411a$

$$x=\frac{199-411a}{176}=1-2a+\frac{23-59a}{176}\cdot$$

Let $23-59a=176b$

$$a=-3b+\frac{23+b}{59}\cdot$$

Let $23+b=59c$. Since integral solutions of $x$ and $y$ are desired, $c$, $b$, and $a$ must be integers.

$$b=59c-23$$
$$a=-176c+69$$
$$x=411c-160$$
$$y=1057c-412$$

Since both $x$ and $y$ vary directly as the value of $c$, the sum of $x$ and $y$ varies directly as $c$, and reaches its minimum value with the value of $c$ at its lowest. The least value of $c$ that leaves both $x$ and $y$ positive is 1, so that the values of $x$ and $y$ are as follows.

$$x=251$$
$$y=645$$

Solutions are also offered by John K. Fisher, La Grande, Oregon, Charles

W. Trigg, Los Angeles, Norman Anning, University of Michigan, A. R. Haynes, Tacoma, Washington, Daniel Finkel, Brooklyn, New York, W. E. Buker, Leetsdale, Pennsylvania, Isadore Chertoff, Bayonne, New Jersey, and the proposer.

**1405.** *Proposed by Lester Dawson, Wichita, Kansas.*

If $P_1$, $P_2$, $P_3$, $P_4$ be the vertices of a plane quadrilateral, in counterclockwise order, prove that the

$$\text{Area} = \tfrac{1}{2}\begin{vmatrix} X_1 & Y_1 & 1 & 1 \\ X_2 & Y_2 & 0 & 1 \\ X_3 & Y_3 & 1 & 1 \\ X_4 & Y_4 & 0 & 1 \end{vmatrix}$$

Solution by the Proposer.

Proof: The area is the sum of the areas of the triangles whose vertices are $(x_2, y_2)$, $(x_3, y_3)$, $(x_4, y_4)$ and $(x_1, y_1)$, $(x_2, y_2)$, $(x_4, y_4)$. Therefore

$$\text{Area} = \tfrac{1}{2}\left[\begin{vmatrix} x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \\ x_4 & y_4 & 1 \end{vmatrix} + \begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_4 & y_4 & 1 \end{vmatrix}\right]$$

$$= \tfrac{1}{2}\left[\begin{vmatrix} x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \\ x_4 & y_4 & 1 \end{vmatrix} - 0\cdot\begin{vmatrix} x_1 & y_1 & 1 \\ x_3 & y_3 & 1 \\ x_4 & y_4 & 1 \end{vmatrix} + 1\cdot\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_4 & y_4 & 1 \end{vmatrix} - 0\cdot\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix}\right]$$

$$= \tfrac{1}{2}\begin{vmatrix} 1 & x_1 & y_1 & 1 \\ 0 & x_2 & y_2 & 1 \\ 1 & x_3 & y_3 & 1 \\ 0 & x_4 & y_4 & 1 \end{vmatrix} = \tfrac{1}{2}\begin{vmatrix} x_1 & y_1 & 1 & 1 \\ x_2 & y_2 & 0 & 1 \\ x_3 & y_3 & 1 & 1 \\ x_4 & y_4 & 0 & 1 \end{vmatrix}$$

Solutions were also offered by Charles C. D'Amico, Albion, N.Y., David Gordon, Norfolk, Virginia, Isadore Chertoff, Bayonne, N.J., Charles W. Trigg, Los Angeles, A. R. Haynes, Tacoma, and W. E. Buker, Leetsdale, Pa.

## HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

## PROBLEMS FOR SOLUTION

**1418.** *Proposed by Cecil B. Read, Wichita.*

If $x^3+y^3+z^3=(x+y+z)^3$, prove that for any positive integer, $K$ $x^{2K+1}+y^{2K+1}+z^{2K+1}=(x+y+z)^{2K+1}$.

**1419.** In triangle $ABC$, $AF$, $BD$, and $CE$ are cevians. $AF$ is perpendicular $BC$, $BD$ meets $FE$ at $K$, $CE$ meets $FD$ at $G$ and $ED$ meets $BC$ at $L$. Prove that $L$, $K$, and $G$ are collinear.

**1420.** *Proposed by Dewey C. Duncan, Compton, California.*

If $\alpha$ and $\beta$ are positive integers and $\beta>2$, then $2^\alpha+1$ is never divisible by $2^\beta-1$.

**1421.** *Proposed by Hyman Zalosh, New York City.*

Without using analytic geometry construct triangle $ABC$ given side $a$, the median to $a$ and the bisector of angle $A$. ($a$, $Ma$, $ta$).

**1422.** *Proposed by A. R. Haynes, Tacoma, Washington.*

If $A+B+C=360°$, prove: $\cos^2 A+\cos^2 B+\cos^2 C=1+2\cos A\cos B\cos C$.

**1423.** *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

In a variable triangle with a fixed base, the sum of the tangents of the base angles is constant, $=K$. Determine the locus of the vertex of the triangle and discuss the locus for various values of $K$.

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# SCIENCE QUESTIONS

**December, 1935**

**Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.**

TELL ME, PLEASE! How can I have an interesting and good "Science Questions," unless *You Send Me the Material? Just address Jones, 10109 Wilbur Ave, S. E., Cleveland, Ohio.*

Thanks!

## HALO—SINNER

**726.** *Asked by Norman Anning (GQRA, No. 101), Ann Arbor, Mich.*

Just before sunset a sinner stands on a hill and looks at his shadow on a distant pasture field.

What is the reason for the halo?

---

**672.** The answer should be 10.016 cu. ft. (The decimal point was displaced and *ED.* did not catch the mistake) *Walter C. Pribnow answered (GQRA, No. 3), Sparta, Wis. also Margaret Joseph (GQRA, no. 27), Shorewood H.S., Milwaukee, Wis.*

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## A TIP ON 720 (October, 1935)

Try re-writing the statement so that the witch *can* break the deadlock by speaking "two words."

---

## EXPLAIN TIDES SIMPLY

**727.** *Proposed by R. H. Gocker (Elected to GQRA, No. 112) Oak Park and River Forest Township High School, Oak Park, Ill.*

Dear Mr. Jones:

My classes in General Science have just finished a unit of work which involved a study of tides. Some discussion arose as to the cause of the high tide on the side of the earth opposite the sun and moon.

Upon consulting reference books we found little agreement on the subject except for the fact that it was a complex problem. Some authors explain the phenomena on the basis of gravitational force alone while others enlist the centrifugal force of rotation and revolution.

The question might be stated as follows:

*What are the roles if any, played by gravitational and centrifugal force in producing a high tide on the side of the earth opposite the sun and moon?*

I would appreciate a discussion of the subject in your column in SCHOOL SCIENCE AND MATHEMATICS.

## VACATION QUESTIONS AND ANSWERS

**716.** *Contributed by Leona Millard, James Ford Rhodes High School, Cleveland, Ohio. (Elected to GQRA, No. 92.)*

### Are You a Sherlock Holmes?

A young man and his wife started from England for a vacation in the Swiss Alps. While climbing a mountain the woman fell over a cliff and was killed. The Swiss Coroner decided that the death was accidental and it was so reported in Continental papers.

Back in England a man read this newspaper report and informed the police that the husband had murdered his wife, which turned out to be the case.

What mistake did the husband make which caused him to be detected in murder?

---

*Answer by Maxwell Reade, (GQRA, No. 48), Brooklyn, N.Y.*

My guess is that the young man forgot to mention the rope that mountain travelers use for safety purposes. You know the rope that is tied about the waist of each member of the party—so that in case one member falls he is hauled to safety by his comrades. In this case I believe the accused forgot to explain how that rope came loose so that he couldn't help his wife.

---

*Answer by Jerome L. C. Formo (GQRA, No. 102).*
*Augsburg College, Minneapolis, Minn.*

In answer to Problem No. 716 found also in the June issue let me offer a solution. It is usual on extended vacations such as this man and his wife were to take that all transportation arrangements be made in advance. Consequently, railroad and steamer tickets were more than likely purchased for the couple before leaving England. If the husband purchased one round trip ticket and one one-way fare, this fact would seem to point to premeditated murder. The one man in England who could upset his "perfect crime" naturally would be the ticket agent who sold the man the tickets. For trips to foreign countries signatures are asked even for tickets, so it is probable that the ticket agent having made special notice of such a luxury trip also would remember the man's name when it was flashed before him in the newspapers. This theory would be more applicable perhaps if the couple had started from Scotland, although I do not wish to enter into any dispute with any Scotchman about their reputed "stinginess."

(As you will probably suspect, I am a student, a Junior, at Augsburg College and am majoring in Chemistry and Math. Therefore anything of that nature is of interest to me and I find your little magazine quite interesting recreational reading. Often when I am tired of studying, I will glance thru your magazine and pick out some problem to work on. Whether or not I am able to get the correct answer matters little, for I get a rest by centering my attention on something more pleasant. Thank you for your part in giving me that help in my work.)

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### Those Lath Marks: Further Discussion

**711.** *Proposed by R. T. Harling, Memorial University College, St. Johns, Newfoundland. (Elected to GQRA, No. 68.)*

I should like to propose the following for your "Science Questions." I have sought in vain for an answer in the textbooks.

"When dust settles on the plastered walls and ceiling of a room, it does not do so evenly. After it has accumulated sufficiently, the rafters and laths behind the plaster may be seen clearly worked out in a lighter tone than the remainder. How does the woodwork behind an inch thickness of plaster affect the settling of dust on the surface? Further, if there is a crack in the plaster of a vertical wall, the plaster on the lower side of the crack remains much cleaner than that on the upper side; and all edges where two walls meet also remain markedly free from deposit. What is the reason for these facts?"

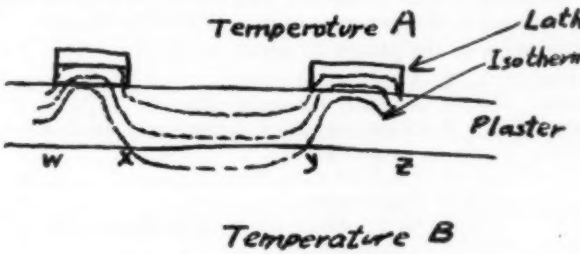
---

*Answer by Gilbert H. Fett (GQRA, No. 95).*

This is a reply to your card of the 2nd and Q 711.

The following quotation may answer your suggestion of dust deposition or stain of plaster by means of filtration. " . . . the most plausible being that there is a filtration of dust particles. To prevent this filtration, and the adhesion of dust particles, high gloss paints, paper, and lead foil have been tried on a plaster surface, but in every case, in a comparatively short time after redecoration the stains reappeared."[1] Evidently diffusion of dust from the back of the plaster is not the cause of stain.

In tests made by Bonnell and Burridge the same conclusion was reached as from those of Prof. Hooper, i.e., temperature gradients on the surface of the plaster due to unhomogeneous thermal conductivities at the back of the plaster cause dust to be deposited on the cooler parts of the surface.




If $A < B$, $xy$ will be colder than $wx$ and $yz$ and dust will be deposited along $xy$.

If $A > B$, $xy$ will be warmer than $wx$ and $yz$ and dust will be deposited along $wx$ and $yz$.

From observations I have made, the conclusion drawn by the Bureau of Standards[2] (an unsigned article which is a digest of opinions with little experimental evidence) that painting with a high gloss paint will stop dust patterns is, I believe, erroneous. During the summer I have made some simple tests on a miniature wall section constructed with wires buried in the plaster, so that the plaster could be heated in certain spots. While the results were not conclusive, for I could not conveniently cool the wires, the dust certainly deposited on the cooler parts of the wall section, and there was no evidence of moisture deposition or dew formation.

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[1] "Prevention of Pattern Staining of Plasters." Bonnell & Burridge, from Building Research Bulletin No. 10, Dept. of Scientific and Industrial Research, Great Britain, Feb., 1931.

(This paper has a photograph of a "fine" example of dust deposition in the forms of patterns of the various supporting members behind the plaster. The little sketch is borrowed from this paper.)

[2] Bureau of Standards Circular No. 151, 1924, p. 58.

The reason for dust deposition on a cold surface rather than hot is the same as that for the motion of a Crookes radiometer, i.e. the microscopic dust particles in contact with the surfaces experience a differential force in the direction of the cold surface.

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*Remarks by R. T. Harling on answers published in October, 1935.*

You suggest that vibration is the explanation of the "lath marks" so often seen on ceilings and walls. This is an explanation I have heard before, but frankly, I don't believe it: first, because I feel certain that somewhere and sometime, I have seen a much more completely satisfying explanation, but have forgotten where to turn for it, and cannot remember what it is. More logical perhaps, if vibration were the cause, the pattern would surely differ in distinctness at the middle and ends of the rafters and beams, and its distinctness would also vary with the size and shape of the woodwork. Actually it seems just about equally plain in the center of a span as at the ends, and for thin as for thick beams.

## Cleveland Biology Test

**728.** *Distributed by L. J. Rentsch (Elected to GQRA, No. 113) at a recent meeting of the Northeastern Ohio Teachers Association in connection with a paper, "A Testing Program for Biology."*

Grade 10A Test I Form A

Directions: Read the statement in the column at the right, then find the item in the column at the left that best fits or completes the meaning of that statement. Put the NUMBER of that word or words in the parentheses provided at the right.

Sample: The name of the planet on which we live..........( 21 )

| | | | |
|---|---|---|---|
| 1. arbor vitae | 1. A salt water animal.............. | ( ) | 1. |
| 2. black bass | 2. An early blooming plant.......... | ( ) | 2. |
| 3. cerebrum | 3. Organism which preys upon another organism.................... | ( ) | 3. |
| 4. codfish | 4. Used for shrubbery.............. | ( ) | 4. |
| 5. egg | 5. Scavengers...................... | ( ) | 5. |
| 6. fission | 6. Gland which produces male sex cells. | ( ) | 6. |
| 7. gulls | 7. Unlearned behavior.............. | ( ) | 7. |
| 8. instinct | 8. Formed by living processes........ | ( ) | 8. |
| 9. legumes | 9. A nerve cell and its branches....... | ( ) | 9. |
| 10. mammals | 10. Front part of the brain........... | ( ) | 10. |
| 11. neuron | 11. Vertebrates with milk-secreting glands | ( ) | 11. |
| 12. organic | 12. Nutrients composed chiefly of carbon, hydrogen, oxygen, nitrogen....... | ( ) | 12. |
| 13. parasite | 13. Tendency of plants to grow towards light.......................... | ( ) | 13. |
| 14. phototropism | 14. Division of mother cell into two daughter cells.................. | ( ) | 14. |
| 15. protein | 15. Depositing of eggs by fish.......... | ( ) | 15. |
| 16. response | | | |
| 17. skunk cabbage | | | |
| 18. spawning | | | |
| 19. spermary | | | |
| 20. urine | | | |
| 21. earth | | | |

---

| | | | |
|---|---|---|---|
| 1. analogy | 1. Plant having only one seed leaf..... | ( ) | 1. |
| 2. appendix | 2. Stone-like remains of organisms..... | ( ) | 2. |
| 3. budding | 3. The most intelligent animals....... | ( ) | 3. |
| 4. Charles Darwin | 4. A family of low grade criminals..... | ( ) | 4. |

5. dominant
6. Edwards
7. embryology
8. eugenics
9. fossil
10. gestation period
11. Gregor Mendel
12. Huxley
13. Jukes
14. Lamarck theory
15. metamorphosis
16. monocotyl
17. mutant
18. primates
19. sterile
20. variation

5. A sexual reproduction in certain plants and animals.................... ( ) 5.
6. Lacking reproductive power........ ( ) 6.
7. Advanced the theory of evolution by natural selection................ ( ) 7.
8. A complete change in form undergone by growing organisms........... ( ) 8.
9. Characters which appear in a hybrid. ( ) 9.
10. Study of the improvement of offspring ( ) 10.
11. Offspring which is an abrupt change from parent type............... ( ) 11.
12. Slight deviation from parental type. ( ) 12.
13. Discovered laws of heredity........ ( ) 13.
14. Similarity between organs with respect to function................ ( ) 14.
15. Study of the development of organisms before birth................. ( ) 15.

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**729.** *A College Entrance Examination in Biology.*



### Biology

**Wednesday, June 19, 1935** **2 P.M. Two hours**

**Answer eight questions only, numbering your answers to correspond with the questions selected.**

1. *a)* Describe briefly a biological field trip taken by you, indicating the nature of the localities visited.
   *b)* Make a list of ten animals and ten plants observed on this or other trips.
   *c)* For each of five of these organisms give one characteristic of structure, or of habit, or of habitat, which would aid in its identification in the field.
2. Select any six of the following names, and for each of the men selected briefly state his major contribution to biology.

| | |
|---|---|
| Harvey | De Vries |
| Linnaeus | Morgan |
| Weismann | Pasteur |
| Mendel | Lister |
| Lamarck | Koch |

3. Outline and illustrate with labeled diagrams the life-history of a fern.
4. *a)* Make and label a diagram to illustrate the nitrogen cycle, showing at least five steps.
   *b)* Explain why both plants and animals are necessary to the process.
5. *a)* Write a brief essay in which eight of the following terms or phrases are correctly used: variation, acquired character, natural selection, fossil, mutation, germ cell, environment, adaptation, Archaeopteryx, vestigial, spontaneous generation.
   *b)* Give an appropriate title to your essay and underscore in your answer each of the terms or phrases selected.
6. *a)* List the physiological properties of protoplasm.
   *b)* Using the frog as an example, indicate the organs or organ systems in which these properties are particularly evident.

7. Explain or criticize any five of the following statements:
   a) A plant may wilt on a hot day even though the soil in which it is growing is abundantly supplied with water.
   b) The increase in weight of a plant does not accurately represent the amount of photosynthesis which has taken place in it.
   c) Monocotyledonous plants can be readily grafted.
   d) Proteins, in man, are digested only in the stomach.
   e) Goiter is especially prevalent in the region of the Great Lakes.
   f) The contractile vacuole of the amoeba and the lung of the frog perform similar functions.
8. Make and label a drawing, or drawings, showing the internal structure of the earthworm as seen in a dissection.
9. Select six of the following structures and in each case give (*a*) the organism concerned, (*b*) location in the organism, and (*c*) the special function:

| | |
|---|---|
| chloroplastid | endosperm |
| tympanum | spiracle |
| antheridium | pyrenoid |
| thyroid | ganglion |

10. a) Cite three conservation laws, either federal or state, which you would have to observe if you were collecting specimens of fishes and birds for a local museum and had no special permit.
    b) Name four vertebrate animal forms of the United States which in the interests of civilization should be controlled or exterminated. Give reasons.
    c) Give three biological reasons for bird conservation, naming a specific bird in each instance.

**Have you answered eight questions?**
**If you have answered more than eight questions, cross out the one or ones that you do not wish to have count.**

## SOME QUESTIONS YOU HAVE MISSED

Nos. 676, 675, 703–709, 717, 725.

TEACHERS!!! *Put up these problems and questions to your classes.*
You and/or your class become members of the **GUILD OF QUESTION RAISERS AND ANSWERS** (GQRA) when you send an accepted communication to **SCIENCE QUESTION DEPT.** of SCHOOL SCIENCE AND MATHEMATICS.

**Have your class answer or propose a question.**

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## BOOKS RECEIVED

*The Story of the Plant Kingdom,* by Merle C. Coulter, Professor of Botany, The University of Chicago. Cloth. Pages ix+270. 15×23 cm. 1935. The University of Chicago Press, Chicago, Ill. Price $2.50.

*First Course in Algebra,* by Harry C. Barber, Instructor in Mathematics in the English High School, Boston, and Elsie Parker Johnson, Instructor

in Mathematics, Oak Park and River Forest Township High School, Oak Park, Ill. Cloth. Pages iv+425+xiii. 12.5×18.5 cm. 1935. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.24.

*Laboratory and Workbook Units in Chemistry*, by Maurice U. Ames, Chairman, Department of Physical Sciences, George Washington High School, New York City, and Bernard Jaffe, Chairman, Department of Physical Sciences, Bushwick High School, New York City. Nonconsumable Edition. Cloth. Pages xiv+240. 13.5×20 cm. 1935. Silver, Burdett and Company, 39 Division Street, Newark, N. J. Price $1.08.

*Laboratory and Workbook Units in Chemistry*, by Maurice U. Ames, Chairman, Department of Physical Sciences, George Washington High School, New York City, and Bernard Jaffe, Chairman, Department of Physical Sciences, Bushwick High School, New York City. Consumable Edition. Paper. Pages xii+228. 19×26 cm. 1935. Silver, Burdett and Company, 39 Division Street, Newark, N. J. Price 84 cents.

*The Algae and Their Life Relations*, by Josephine E. Tilden, Professor of Botany, University of Minnesota. Cloth. Pages xii+550. 15×23.5 cm. 1935. The University of Minnesota Press, Minneapolis, Minn. Price $5.00.

*A Fugue in Cycles and Bells*, by John Mills. Cloth. Pages vi+269. 13×20.5 cm. 1935. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.00.

*Modern Pure Solid Geometry*, by Nathan Altshiller-Court, Professor of Mathematics, University of Oklahoma. Cloth. Pages x+311. 14×21.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.90.

*Handbook of the Heavens*, Sponsored by The American Museum of Natural History. Edited by Hubert J. Bernhard, Director of Publications, Junior Astronomy Club; Dorothy A. Bennett, Assistant Curator of the Hayden Planetarium, Adviser, Junior Astronomy Club; and Hugh S. Rice, Associate in Astronomy, American Museum, Scientific Associate, Junior Astronomy Club. Cloth. Pages xvi+131. 15×23 cm. 1935. Whittlesey House, McGraw-Hill Building, 330 West 42nd Street, New York, N. Y. Price $1.00.

*Handbook of Chemistry and Physics*, Twentieth Edition. Editor in Chief, Charles D. Hodgman, Associate Professor of Physics at Case School of Applied Science. Cloth. 1966 pages. 16.5×10.5 cm. 1935. Published by Chemical Rubber Publishing Company, Cleveland, Ohio. Price $6.00.

*An Open Letter to College Teachers*, by Fernandus Payne, Professor of Zoology and Dean of the Graduate School, Indiana University, and Evelyn Wilkinson Spieth, Department of Biology, The College of the City of New York. Cloth. Pages xiii+380. 15×22.5 cm. 1935. The Principia Press, Inc., Bloomington, Indiana.

*Eclipses of the Sun*, by S. A. Mitchell, Professor of Astronomy at the University of Virginia and Director of the Leander McCormick Observatory. Fourth Edition. Cloth. Pages xvii+520. 15×22.5 cm. 1935. Columbia University Press, 2960 Broadway, New York City. Price $5.00.

*A Mathematician Explains*, by Mayme I. Logsdon, Associate Professor of Mathematics, The University of Chicago. Cloth. Pages xi+175. 16.5×23 cm. 1935. The University of Chicago Press, 5750 Ellis Ave., Chicago, Ill. Price $2.00.

*Holiday Hill*, by Edith M. Patch. Cloth. 135 pages. 18×20.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 96 cents.

*Holiday Meadow*, by Edith M. Patch. Cloth. 165 pages. 18×20.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 96 cents.

*Holiday Pond*, by Edith M. Patch. Cloth. 147 pages. 18×20.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 96 cents.

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## BOOK REVIEWS

*The Calculation of the Orbits of Asteroids and Comets*, by Kenneth P. Williams, Professor of Mathematics, Indiana University. Cloth. Pages vii+214. 17×25.5 cm. 1934. The Principia Press, Inc., Bloomington, Indiana.

This book is intended to introduce the student of mathematics into the theory and practice of orbit calculation, to give to him, who has mastered his differential and integral calculus and differential equations—not to forget also spherical trigonometry, this stepchild of our college curriculum—a first acquaintance with "mathematics in the grand manner" as it unfolds itself in celestial mechanics. Really a fair degree of familiarity with the basic facts and concepts of astronomy would seem indispensable as a further prerequisite, even though the explanations given in the beginning appear to take no such knowledge for granted.

There are two introductory chapters, one on astronomical coordinates, their definitions, their measurement, their interrelations; the second on methods of interpolation in case higher than the first differences have to be taken into account. The formulae of Newton, Bessel, Stirling, and Lagrange are given without proof, the whole emphasis being laid on showing how they are used to define the value of a function and its derivatives between empirically given values.

Next the problem of orbits as such is taken up, beginning with the classical theory of the Two-Bodyproblem restricted to the case that the mass of the one body is negligible in comparison to that of the other. (It is this restriction which makes this theory one of asteroids and comets rather than of any gravitating body in the solar system; more accurately, it is the theory of undisturbed comets and asteroids only, since perturbations are not being considered.) The next three chapters deal with the problem of determining the six elements of the orbital motion from three observations, first after the method of Laplace modified by the method of differential correction by Leuschner, this latter theory, however, being presented in a form which is the author's own contribution and which aims at the utmost simplicity and intelligibility in the procedure; secondly the method of Gauss, with the formulae adapted to calculating machines rather than to logarithms; and lastly Olber's method of determining parabolic cometary orbits. A last chapter is given to the converse problem, the calculation of positions for given times from the known elements of the orbit, that is, the construction of an ephemeris.

In each chapter the theoretical solution is followed by a concise summary of all the steps of the procedure, by a complete numerical example, and many and varied interesting exercises. The mathematical-astronomical tables necessary for the calculations are not given in the book.

An outstanding feature—aside from the above mentioned modification of the theory is the constant emphasis on the historical development. Every chapter is followed by a brief but highly significant and interesting historical sketch with many references to and quotations from the original great works, revealing most strikingly and almost dramatically the constant interaction between astronomical discovery and mathematical theory and thereby imparting to the book a much broader cultural interest than texts of the kind are apt to possess.

Certain types of readers, with a specially keen appetite for strict mathematical development, might perhaps prefer to have these historical comments restricted to the separate sections rather than have them invade—at times quite thickly—the presentation of the mathematical theory as such. A few more figures in the text would, in our opinion, have been helpful; also, perhaps, more prominent type for the most important formulae to which frequent reference is made.

L. LANGE

*Science and The Public Mind*, by Benjamin Gruenberg, with a Foreword by John C. Merriam, President of Carnegie Institute of Washington. Cloth. 196 pages. 13×19 cm. 1935. McGraw-Hill Book Company, Inc. New York. Price $2.00.

Science and The Public Mind is a very timely book. The needs and popularity of the Adult-Education program, which has made great advances in the past three years, call for new books on science. Our formal education in science treats the later as a producer of wealth. The author of this book considers science in its influence upon our modes of thought and manner of life. He sets forth the general conditions, trends and outstanding needs of the Adult-Education program with respect to science, and discusses means and methods of bringing science to the public.

C. RADIUS

*A History of Magic and Experimental Science*, Vols. III and IV, Fourteenth and Fifteenth Centuries, by Lynn Thorndike, Professor of History, Columbia University. Cloth. 14×22 cm. Vol. III, 827 pages, Vol. IV, 767 pages. Columbia University Press. New York. Price $10.00. (Not sold separately.)

Professor Thorndike has collected a wealth of new information from a great mass of manuscript material of the fourteenth and fifteenth centuries. No longer can it be said that we have scattered notices and only fragments of the beginnings of science. This work is truly a story of the great activity found during these centuries. After a brief survey one begins to comprehend what superstition and vagaries scientific progress had to contend with and yet how much science owes to these very stumbling blocks. The citation from the original manuscript and continual reference to the original sources makes this work the most reliable in its field.

C. RADIUS

*A Scientist in the Early Republic*, by Courtney Robert Hall. Cloth. Pages vi+162. 15×23 cm. 1934. Columbia University Press, 2960 Broadway, New York City. Price $2.50.

In "A Scientist in the Early Republic" the author presents a vivid account of the career of Samuel Latham Mitchell, pioneer American scientist and man of letters. Mitchell's rôle in American science during the formative period of the nation, his versatile genius in such fields as ichthyology, mineralogy, herpetology, oceanography, and many others, his contacts with European authorities of better known reputation, are all discussed with reference to their importance in the cultural and intellectual standards of the times. As a scientist of first rank Mitchell stands out in an otherwise unproductive period; as a leader in the social and political life of his community, he was no less important. The book tends to focus the attention of its readers upon a character quite unrepresentative of the

age in which he lived, and far above his contemporaries according to most cultural standards. The life of Mitchell comes as a welcome addition to the history of American Science and should prove to be a special relief in an age where specialization is so great that few, if any, individuals occupy a leading position in more than one branch of scientific learning.

J. F. SCHUETT

*Principles of Genetics and Eugenics*, by Nathan Fasten, Professor and Head of Department of Zoology, Oregon State College. Cloth. Pages viii+407. 14×21 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Massachusetts. Price $2.80.

This excellent textbook of Genetics and Eugenics should be welcomed by all those who conduct courses in the principles of Heredity. Professor Fasten has presented the fundamentals of the subject in a clear and interesting fashion, including in his work a large number of illustrations, many of which are new and original. Standard chapters on Mendelian inheritance, the gene hypothesis, linkage and crossing-over are augmented by sections involving variation and species making, improvement of organisms, and monstrosities. A considerable portion of the book is devoted to a discussion of the problems of eugenics, a subject badly neglected if not omitted in most treatments of this general topic. In material the book is quite up to date, making extensive use of recent investigations and giving proper evaluations of their importance in the general setting.

This work should prove to be of value in elementary college courses where a previous knowledge of biology is not always possible, as well as a reference for many high school courses where an introduction to this field forms part of the subject matter to be covered. A glossary of twenty-two pages and a bibliography of 213 titles increases the utility of the book from a practical standpoint.

J. F. SCHUETT

*The Principles of Heredity*, by Laurence H. Snyder, Professor of Zoology, Ohio State University. Cloth. Pages xiii+385. 14.5×22.5 cm. 1935. D. C. Heath and Company, 285 Columbus Avenue, Boston, Massachusetts. Price $3.00.

In this textbook Dr. Snyder has given a scholarly presentation of the facts and principles of heredity. In general the book appears to be somewhat above the level at which the majority of semester courses in genetics are conducted, but if the readers are fortified with an acquaintance of the rudiments of either botany or zoology, this work should be of tremendous value. The subject matter, aside from the orthodox chapters in Mendelian inheritance, one and two factor cases, allelomorphism, linkage, crossing-over, mutations, etc.—contains some interesting and instructive sections dealing with the gentics of domestic animals and cultivated plants, lending a practical atmosphere to the entire book. The final chapter on the analysis of family histories involves a considerable statistical ability, but for elementary class work this section can well be omitted without interrupting the continuity of the thought. The book is well illustrated and contains many carefully prepared diagrams. Each chapter contains, in addition to a few select references, a list of problems which add materially to its value as a textbook.

J. F. SCHUETT

*Twelve Hours of Hygiene*, by F. L. Meredith, Professor of Hygiene, Tufts College, Lecturer on Hygiene, Simmons College. Cloth. 110 illustrations.

14.5×21 cm. 1935. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $1.90.

The purpose of this book is for use in one semester courses in Hygiene for college freshman. The book is divided into 12 chapters, each concerned with some fundamental problem of sanitation and hygiene. The order of topics is logical—starting with an analysis of the human body and its various systems together with the rudiments of their physiological activity. This treatment is followed by sections dealing with the value and prevention of disease, the upkeep and energy supply of the body, digestion and elimination, use of energy in activities, body mechanics, thermal regulation, cleanliness, inspection and resistance, and reproduction in sex. In view of the extensive field the material appears to be exceptionally well chosen, the size of the book not permitting an exhaustive treatment of any particular topic. An appeal to the natural interest of the readers is noticeable throughout and examples illustrating the numerous principles are invariably selected from the everyday experience of the average student. The book contains valuable appendices upon such topics as, food composition, calorie portions, mineral content of foods, communicable diseases and immunity to various of these diseases. Instructors in hygiene will find this book stimulating and useful in their courses.

J. F. SCHUETT

"*Plane Trigonometry*," by H. L. Rietz, Professor of Mathematics, University of Iowa, J. F. Reilly, Professor of Mathematics, University of Iowa, and Roscoe Woods, Associate Professor of Mathematics, University of Iowa. 1935. Cloth. Pages x+142+72 (Tables)+x (Answers & Index). The Macmillian Company, New York.

The authors present the subject of Plane Trigonometry primarily to meet the needs of first year students in Colleges and Technical Schools.

This book represents the results of an attempt to work out the cardinal principle of introducing only one important new idea at a time, and of offering guidance in teaching by emphasis on essentials.

The treatment and development of the subject matter might be classified as traditional, although the authors have constantly in mind the limitations and difficulties which students encounter in their study of the subject.

The contents of the book are as follows:

1. Trigonometric functions of an acute angle.
2. Simple application: Solution of right triangles.
3. Trigonometric functions of any angle.
4. Trigonometric identities.
5. Variation of the trigonometric functions, line values. Graphs.
6. Law of sines-law of cosines-applications.
7. Additional theorems and related formulas.
8. Logarithms.
9. Solution of triangles by logarithms.
10. Radian measure of angles.
11. Inverse trigonometric functions.
12. Trigonometric equations.

The book contains an index, answers to odd numbered problems, which will be useful to many teachers, and tables which are essential to a well rounded course in Trigonometry. In addition the authors have included outlines for courses of thirty and forty-five lessons respectively.

Numerous applications, exercises, and problems aid the pupil, materially to a thorough understanding of the subject-matter.

The book is well-written, well organized, clear, concise, and will be welcomed by teachers who have in mind the interests of their pupils.

HYMEN D. SILVERMAN

"*Plane Geometry*," (New Edition) by Arthur Schultze, Ph. D., formerly assistant Professor of Mathematics, New York University, and head of the Mathematical Department, High School of Commerce, New York City, and Frank L. Sevenoak, formerly Principal of the Academic Department, Stevens Institute of Technology. Revised by Limond C. Stone—Department of Mathematics, Boys' High School, Brooklyn, New York. Principal Brooklyn Evening High School. 1935. Cloth. Pages xii+391. The Macmillan Company, New York.

This volume being the third revision contains the essential and distinctive features of the original text. The authors have ever in mind their basic principle of introducing the student systematically to original geometrical manipulation and thinking. Careful and thoughtful consideration has been exercised in order to see that the selection and arrangement of materials should be in a logical and pedagogical order.

In the preface to the new edition, the authors state the following points which are worthy of consideration.

1. The more thorough and deliberate development of the introduction to formal geometry by means of additional construction work, and practice with the protractor, together with a liberal quantity of numerical exercises.
2. The importance of construction.
3. The very thorough treatment of the subject of loci.
4. The book contains all the material needed by the teacher for a thorough presentation of the subject.
5. The explanation, the development, and application of the trigonometric functions not limited to angles of 30°, 45°, and 60°.
6. There is frequent references to three-dimensional space and the necessary modification of plane concepts.
7. Numerical and construction exercises used abundantly to illustrate and make concrete the meaning of a new theorem.
8. Propositions and additional work for students who wish to go further, are placed in the appendix.

The book contains an index of definitions, many miscellaneous exercises, cumulative reviews, and many practical applications. Teachers of Mathematics will find this book a very valuable and important aid in their work.

HYMEN D. SILVERMAN

*Modern Radio Servicing*, by Alfred A. Ghirardi. Cloth. Pages x+1300. 706 Illustrations, 13.5×20.5 cm. 1935. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $4.00.

This book is a revision of the "Radio Servicing Course" which the author brought out a few years ago but is so completely changed and enlarged that it is in reality a new book. While it is eminently practical and gives definite and accurate directions for constructing, installing, testing and repairing radios and radio apparatus of all types, theory is not neglected. Fundamental principles of electricity and their application to radio circuits are presented in easy, understandable language. Special features are the latest methods of locating and eliminating noises and interference, installation and servicing auto radios, a chapter on the problems of high-fidelity receivers, and a chapter of useful tips on selling your

services, merchandising, advertising, etc. The book is adapted for either individual study and reference or for class use.

G. W. W.

*Radio Field Service Data*, by Alfred A. Ghirardi. Paper. Pages viii+240. 14×20.5 cm. 1935. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price $1.50.

This is a supplement to *Modern Radio Servicing* put up in flexible cover to be carried along in the tool kit. It contains an outline of trouble symptoms and remedies for all makes and models, electrical wiring diagrams of most of the automobiles now in use, receiver trouble-shooting chart, radio tube characteristic chart, and all the definitions, conversion tables, formulae, charts, graphs, and data needed for any sort of servicing job.

G. W. W.

*Fundamentals of College Mathematics*, by Charles Harold Helliwell, Arthur Tilley and Howard Elmer Wahlert of the Department of Mathematics, Washington Square College, New York University. Cloth. Pages xiii +406. 14×20 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

This book contains sufficient material for a ten hour course in freshman college mathematics. The first six chapters deal with such topics as the number system of algebra, functions and graphs, simultaneous and quadratic equations, general methods of solving nth degree equations, and exponents and logarithms. Chapters VII, VIII, and IX deal with trigonometric functions, solution of triangles, and analysis. The first nine chapters furnish material for one semester.

Material for the second semester is contained in the chapters from X to XVII inclusive. Chapter X deals with the coordinate geometry of the straight line. Chapter XI discusses limits. Chapters XII, XIII, and XIV deal with differentiation of algebraic functions, applications of differential calculus, and integration of algebraic functions. Chapter XV deals with coordinate geometry of the conic sections. The only application of calculus found in this chapter is in the derivation of the equations of the tangent and normal at a point on the parabola. The remaining chapters, XVI to XXI, deal with translation of axes, polar coordinates, trigonometric functions including their differentiation and integration, exponential and logarithmic functions, progressions, expansions, permutations, combinations, and probability.

J. M. Kinney

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4. anger
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8. gluttony
9. uncleanliness
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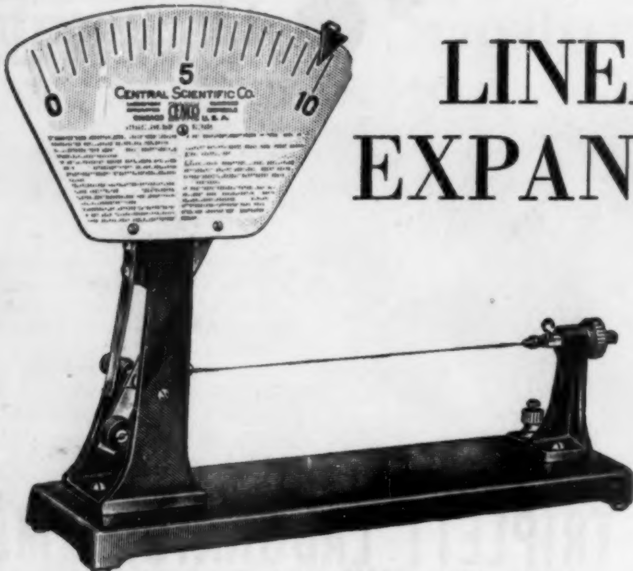


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